SIEMENS

SINUMERIK

SINUMERIK 840D sl / 828D Job Planning

Programming Manual

Valid for

Control
SINUMERIK 840D sl / 840DE sl
SINUMERIK 828D

Software	Version
CNC software	4.5 SP2

03/2013
6FC5398-2BP40-3BA1

Legal information

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

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

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

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Siemens AG
Industry Sector
Postfach 48 48
90026 NÜRNBERG
GERMANY

Order number: 6FC5398-2BP40-3BA1
Ⓟ 04/2013 Technical data subject to change

Preface

SINUMERIK documentation

The SINUMERIK documentation is organized in the following categories:

- General documentation
- User documentation
- Manufacturer/service documentation

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Target group

This publication is intended for:

- Programmers
- Project engineers

Benefits

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

Standard scope

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

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

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

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Information on structure and contents

"Fundamentals" and "Job planning" Programming Manual

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

1. **Fundamentals**

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

2. **Job planning**

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

Availability of the described NC language elements

All NC language elements described in the manual are available for the SINUMERIK 840D sl. The availability regarding SINUMERIK 828D can be found in table "Operations: Availability for SINUMERIK 828D (Page 778)".

Table of contents

Flexible NC programming 1

1.1 Variables

The use of variables, especially in conjunction with arithmetic functions and check structures, enables part programs and cycles to be set up with extremely high levels of flexibility. The system provides three different types of variables.

- System variables

  System variables are variables with a fixed predefined meaning; they are defined in the system and made available to the user. They are also read and written by the system software. Example: Machine data

  The meaning of a system variable is permanently set by the system. However, minor modifications can be made to the properties by the user in the form of redefinition. See "Redefinition of system variables, user variables, and NC language commands (REDEF) (Page 29)"

- User variables

  User variables are variables whose meaning is not known to the system; they are not evaluated by the system. The meaning is defined exclusively by the user.

  User variables are subdivided into:

  – Predefined user variables

    Predefined user variables are variables which have already been defined in the system and whose number simply has to be parameterized by the user via specific machine data. The user can make significant changes to the properties of these variables. See "Redefinition of system variables, user variables, and NC language commands (REDEF) (Page 29)".

  – User-defined variables

    User-defined variables are variables which are defined exclusively by the user and are not created by the system until runtime. Their number, data type, visibility, and all other properties are defined exclusively by the user.

    See "Definition of user variables (DEF) (Page 24)"

1.1.1 System variable

System variables are variables which are predefined in the system and enable access to the current parameter settings of the control, as well as to machine, control, and process states, in part programs and cycles.

Preprocessing variables

Preprocessing variables are system variables that are read and written in the context of preprocessing; in other words, at the point in time at which the part program block in which the system variable is programmed is interpreted. Preprocessing variables do not trigger preprocessing stops.

Main run variables

Main run variables are system variables which are read and written in the context of the main run; in other words at the point in time at which the part program block in which the system variable is programmed is executed. The following are main run variables:

- System variables which can be programmed in synchronized actions (read/write)
- System variables which can be programmed in the part program and trigger preprocessing stops (read/write)
- System variables which can be programmed in the part program and whose value is calculated during preprocessing but not written until the main run (main run synchronized: write only)

Prefix system

In order that they can be specifically identified, the names of system variables are usually preceded by a prefix comprising the $ sign followed by one or two letters and an underscore.

$ + 1st letter	Meaning: Data type
System variables which are read/written during preprocessing	
$M	Machine data [1]
$S	Setting data, protection zones [1]
$T	Tool management data
$P	Programmed values
$C	Cycle variables of ISO envelope cycles
$O	Option data
R	R-parameters (arithmetic parameters) [2]
System variables which are read/written during the main run	
$$M	Machine data [1]
$$S	Setting data [1]
$A	Current main run data
$V	Servo data
$R	R-parameters (arithmetic parameters) [2]

[1] Whether machine and setting data is treated as preprocessing or main run variables depends on whether they are written with one or two $ characters. The notation is freely selectable for the specific application.

[2] When an R-parameter is used in the part program/cycle as a preprocessing variable, the prefix is omitted, e.g. R10. When it is used in a synchronized action as a main run variable, a $ sign is written as a prefix, e.g. $R10.

2nd letter	Meaning: Visibility
N	NCK-global variable (**N**CK)
C	Channel-specific variable (**C**hannel)
A	Axis-specific variable (**A**xis)

Supplementary conditions

Exceptions in the prefix system

The following system of variables deviate from the prefix system specified above:

- $TC_...: Here, the 2nd letter C does not refer to channel-specific system variables but to toolholder-specific system variables (TC= tool carrier).
- $P_ ...: Channel-specific system variables

Use of machine and setting data in synchronized actions

When machine and setting data is used in synchronized actions, the prefix can be used to define whether the machine or setting data will be read/written synchronous to the preprocessing run or the main run.

If the data remains unchanged during machining, it can be read synchronous to the preprocessing run. For this purpose, the machine or setting data prefix is written with a $ sign:

```
ID=1 WHENEVER $AA_IM[z] < $SA_OSCILL_REVERSE_POS2[Z]-6 DO $AA_OVR[X]=0
```

If the data changes during machining, it must be read/written synchronous to the main run. For this purpose, the machine or setting data prefix is written with two $ signs:

```
ID=1 WHENEVER $AA_IM[z] < $$SA_OSCILL_REVERSE_POS2[Z]-6 DO $AA_OVR[X]=0
```

Note

Writing machine data

When writing an item of machine or setting data, it is important to ensure that the access level which is active when the part program/cycle is executed permits write access and that the data is set to take "IMMEDIATE" effect.

References

A list of the properties of all system variables appears in:

Parameter Manual, System Variables

See also

Variables (Page 17)

1.1.2 Predefined user variables: Arithmetic parameters (R)

Function

Arithmetic parameters or R parameters are predefined user variables with the designation R, defined as an array of the REAL data type. For historical reasons, notation both with array index, e.g. `R[10]`, and without array index, e.g. `R10`, is permitted for R parameters.

When using synchronized actions, the $ sign must be included as a prefix, e.g. `$R10`.

Syntax

When used as a preprocessing variable:
```
R<n>
R[<expression>]
```

When used as a main run variable:
```
$R<n>
$R[<expression>]
```

Meaning

`R`: Identifier when used as a preprocessing variable, e.g. in the part program

`$R`: Identifier when used as a main run variable, e.g. in synchronized actions

Type: REAL

Range of values: For a non-exponential notation:

± (0.000 0001 ... 9999 9999)

Note:
A maximum of 8 decimal places are permitted.

For an exponential notation:

± ($1*10^{-300}$ ... $1*10^{+300}$)

Note:

- Notation: <Mantisse>EX<exponent> e.g. 8.2EX-3
- A maximum of 10 characters are permitted including sign and decimal point.

`<n>`: Number of the R parameter

Type: INT

Range of values: 0 - MAX_INDEX

Note
MAX_INDEX is calculated from the parameterized number of R-parameters:
MAX_INDEX = (MD28050 $MN_MM_NUM_R_PARAM) - 1

`<expression>`: Array index

Any expression can be used as an array index, as long as the result of the expression can be converted to the INT data type (INT, REAL, BOOL, CHAR).

Example

Assignments to R-parameters and use of R-parameters in mathematical functions:

```
Program code                    Comment
R0=3.5678                   ;   Assignment in preprocessing
R[1]=-37.3                  ;   Assignment in preprocessing
R3=-7                       ;   Assignment in preprocessing
$R4=-0.1EX-5                ;   Assignment in main run: R4 = -0.1 * 10^-5
$R[6]=1.874EX8              ;   Assignment in main run: R6 = 1.874 * 10^8
R7=SIN(25.3)                ;   Assignment in preprocessing

R[R2]=R10                   ;   Indirect addressing using R-parameter
R[(R1+R2)*R3]=5             ;   Indirect addressing using math. expression

X=(R1+R2)                   ;   Traverse axis X to the position resulting from the
                                sum of R1 and R2
Z=SQRT(R1*R1+R2*R2)         ;   Traverse axis Z to the square root position (R1^2 +
                                R2^2)
```

See also

Variables (Page 17)

1.1.3 Predefined user variables: Link variables

Function

Link variables can be used in the context of the "NCU-Link" function for cyclic data exchange between NCUs which are linked on a network. They facilitate data-format-specific access to the link variables memory. The link variables memory is defined both in terms of size and data structure on a system-specific basis by the user/machine manufacturer.

Link variables are system-global user variables which can be read and written in part programs and cycles by all NCUs involved in a link if link communication has been configured. Unlike global user variables (GUD), link variables can also be used in synchronized actions.

On systems without an active NCU link, link variables can be used locally on the controller as additional global user variables alongside global user variables (GUD).

Syntax

```
$A_DLB[<index>]
$A_DLW[<index>]
$A_DLD[<index>]
$A_DLR[<index>]
```

Meaning

`$A_DLB`: Link variable for BYTE data format (1 byte)
Data type: UINT
Range of values: 0 ... 255

`$A_DLW`: Link variable for WORD data format (2 bytes)
Data type: INT
Range of values: -32768 ... 32767

`$A_DLD`: Link variable for DWORD data format (4 bytes)
Data type: INT
Range of values: -2147483648 ... 2147483647

`$A_DLR`: Link variable for REAL data format (8 bytes)
Data type: REAL
Range of values: $\pm(2.2*10^{-308} \ldots 1.8*10^{+308})$

`<index>`: Address index in bytes, counted from the start of the link variable memory
Data type: INT
Range of values: 0 - MAX_INDEX

Note

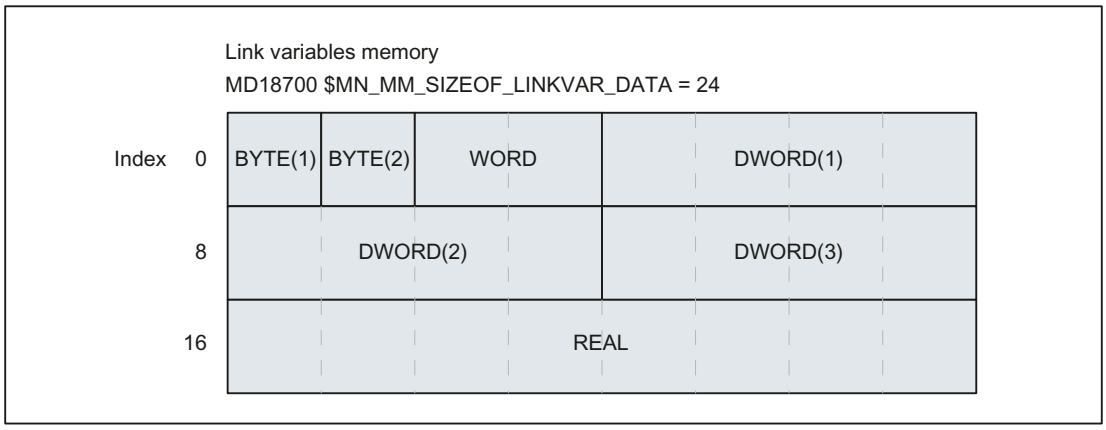
- MAX_INDEX is calculated from the parameterized size of the link variables memory: MAX_INDEX = (MD18700 $MN_MM_SIZEOF_LINKVAR_DATA) - 1
- Only indices may be programmed, so that the bytes addressed in the link variables memory are located on a data format limit ⇒
  Index = n * bytes, where n = 0, 1, 2, etc.
  - `$A_DLB[i]`: i = 0, 1, 2, ...
  - `$A_DLW[i]`: i = 0, 2, 4, ...
  - `$A_DLD[i]`: i = 0, 4, 8, ...
  - `$A_DLR[i]`: i = 0, 8, 16, ...

Example

An automation system contains 2 NCUs (NCU1 and NCU2). Machine axis AX2 is connected to NCU1. It is traversed as a link axis of NCU2.

NCU1 writes the actual current value ($VA_CURR) of axis AX2 cyclically to the link variables memory. NCU2 reads the actual current value transmitted via link communication cyclically and displays alarm 61000 if the limit value is exceeded.

The data structure in the link variables memory is illustrated in the following figure. The actual current value is transmitted in the REAL value.



NCU1

NCU1 uses link variable $A_DLR[16] to write the actual current value of axis AX2 to the link variables memory cyclically in the interpolation cycle in a static synchronized action.

Program code

```
N111 IDS=1 WHENEVER TRUE DO $A_DLR[16]=$VA_CURR[AX2]
```

NCU2

NCU2 uses link variable $A_DLR[16] to read the actual current value of axis AX2 from the link variables memory cyclically in the interpolation cycle in a static synchronized action. If the actual current value is greater than 23.0 A, alarm 61000 is displayed.

Program code

```
N222 IDS=1 WHEN $A_DLR[16] > 23.0 DO SETAL(61000)
```

See also

Variables (Page 17)

1.1.4 Definition of user variables (DEF)

Function

The DEF command is used to define user-specific variables and assign values to them. To set them apart from system variables, these are called user-defined variables or user variables (user data).

According to the range of validity (in other words, the range in which the variable is visible) there are the following categories of user variable:

- Local user variables (LUD)

  Local user variables (LUD) are variables defined in a part program which is not the main program at the time of execution. They are created when the part program is called and deleted at the end of the part program or when the NC is reset. Local user variables can only be accessed within the part program in which they are defined.

- Program-global user variables (PUD)

  Program-global user variables (PUD) are user variables defined in a part program used as the main program. They are created when the part program starts up and deleted at the end of the part program or when the NC is reset. It is possible to access PUD in the main program and in all subprograms of the main program.

- Global user variables (GUD)

  Global user variables (GUD) are NC or channel-global variables which are defined in a data block (SGUD, MGUD, UGUD, GUD4 to GUD9) and are retained following shutdown and restart. GUD can be accessed in all part programs.

User variables must be defined before they can be used (read/write). The following rules must be observed in this context:

- GUD have to be defined in a definition file, e.g. _N_DEF_DIR/_M_SGUD_DEF.
- PUD and LUD have to be defined in a definition section of the part program.
- The data must be defined in a dedicated block.
- Only one data type may be used for each data definition.
- Several variables of the same data type can be defined for each data definition.

Syntax

LUD and PUD

```
DEF <type> <phys_unit> <limit values> <name>[<value_1>, <value_2>,
<value_3>]=<init_value>
```

GUD

```
DEF <range> <pp_stop> <access_rights> <type> <phys_unit> <limit
values> <name>[<value_1>, <value_2>, <value_3>]=<init_value>
```

Meaning

DEF:	Command for defining GUD, PUD, LUD user variables
<range>:	Range of validity, only relevant for GUD:
	NCK: NC-global user variable
	CHAN: Channel-global user variable
<PP_stop>:	Preprocessing stop, only relevant for GUD (optional)
	SYNR: Preprocessing stop when reading
	SYNW: Preprocessing stop when writing
	SYNRW: Preprocessing stop when reading/writing
<access rights>:	Protection level for reading/writing GUD via part program or OPI (optional)
	APRP <protection level>: Read: Part program
	APWP <protection level>: Write: Part program
	APRB <protection level>: Read: OPI
	APWB <protection level>: Write: OPI
	<protection level>: Range of values: 0 ... 7
	See "Attribute: Access rights (APR, APW, APRP, APWP, APRB, APWB) (Page 39)"
<type>:	Data type:
	INT: Integer with sign
	REAL: Real number (LONG REAL to IEEE)
	BOOL: Truth value TRUE (1)/FALSE (0)
	CHAR: ASCII character
	STRING[<MaxLength>]: Character string of a defined length
	AXIS: Axis/spindle identifier
	FRAME: Geometric data for a static coordinate transformation
	See "Data types (Page 52)"
<phys_unit>:	Physical unit (optional)
	PHU <unit>: Physical unit
	See "Attribute: Physical unit (PHU) (Page 37)"
<limit values>:	Lower/upper limit value (optional)
	LLI <limit value>: Lower limit value (lower limit)
	ULI <limit value>: Upper limit value (upper limit)
	See "Attribute: Limit values (LLI, ULI) (Page 35)"

<name>:	Name of variable **Note** • Maximum 31 characters • The first two characters must be a letter and/or an underscore. • The $ sign is reserved for system variables and must not be used.
[<value_1>, <value_2>, <value_3>]:	Specification of array sizes for 1- to max. 3-dimensional array variables (optional) For the Initialization of array variables see "Definition and initialization of array variables (DEF, SET, REP) (Page 45)"
<init_value>:	Initialization value (optional) See "Attribute: Initialization value (Page 32)" For the Initialization of array variables see "Definition and initialization of array variables (DEF, SET, REP) (Page 45)"

Examples

Example 1: Definition of user variables in the data block for machine manufacturers

```
Program code                                                    Comment
%_N_MGUD_DEF                                                    ; GUD block: Machine manufacturer
$PATH=/_N_DEF_DIR
DEF CHAN REAL PHU 24 LLI 0 ULI 10 STROM_1, STROM_2
;Description
;Definition of two GUD items: STROM_1, STROM_2
;Range of validity: Throughout the channel
;Data type: REAL
PP stop: Not programmed => default value = no PP stop
;Physical unit: 24 = [A]
;Limit values: Low = 0.0, high = 10.0
;Access rights: Not programmed => default value = 7 = key-operated switch position 0
;Initialization value: Not programmed => default value = 0.0

DEF NCK REAL PHU 13 LLI 10 APWP 3 APRP 3 APWB 0 APRB 2 ZEIT_1=12, ZEIT_2=45
;Description
;Definition of two GUD items: ZEIT_1, ZEIT_2
;Range of validity: Throughout the NCK
;Data type: REAL
PP stop: Not programmed => default value = no PP stop
;Physical unit: 13 = [s]
;Limit values: low = 10.0, high = not programmed => upper definition range limit
```

Program code	Comment
;Access rights:	
;Part program: Write/read = 3 = end user	
;OPI: Write = 0 = Siemens, read = 3 = end user	
;Initialization value: ZEIT_1 = 12.0, ZEIT_2 = 45.0	
DEF NCK APWP 3 APRP 3 APWB 0 APRB 3 STRING[5] GUD5_NAME = "COUNTER"	
;Description	
;Definition of one GUD item: GUD5_NAME	
;Range of validity: Throughout the NCK	
;Data type: STRING, max. 5 characters	
PP stop: Not programmed => default value = no PP stop	
;Physical unit: Not programmed => default value = 0 = no phys. unit	
;Limit values: Not programmed => definition range limits: low = 0, high = 255	
;Access rights:	
;Part program: Write/read = 3 = end user	
;OPI: Write = 0 = Siemens, read = 3 = end user	
;Initialization value: "COUNTER"	
M30	

Example 2: Global program and local user variables (PUD/LUD)

Program code	Comment
PROC MAIN	;Main program
DEF INT VAR1	;PUD definition
...	
SUB2	;Subprogram call
...	
M30	

Program code	Comment
PROC SUB2	;Subprogram SUB2
DEF INT VAR2	;LUD DEFINITION
...	
IF (VAR1==1)	;Read PUD
VAR1=VAR1+1	;Read & write PUD
VAR2=1	;Write LUD
ENDIF	
SUB3	;subprogram call
...	
M17	

```
Program code                        Comment
PROC SUB3                           ;Subprogram SUB3
...
IF (VAR1==1)                        ;Read PUD
 VAR1=VAR1+1                        ;Read & write PUD
 VAR2=1                             ;Error: LUD from SUB2 not known
ENDIF
...
M17
```

Example 3: Definition and use of user variables of data type AXIS

```
Program code                                Comment
DEF AXIS ABSCISSA                           ;1st geometry axis
DEF AXIS SPINDLE                            ;Spindle
...
IF ISAXIS(1) == FALSE GOTOF CONTINUE
 ABSCISSA = $P_AXN1
CONTINUE:
...
SPINDLE=(S1)                                ;1st spindle
OVRA[SPINDLE]=80                            ;Spindle override = 80%
SPINDLE=(S3)                                ;3rd spindle
```

Supplementary conditions

Global user variables (GUD)

In the context of the definition of global user variables (GUD), the following machine data has to be taken into account:

No.	Identifier: $MN_	Meaning
11140	GUD_AREA_ SAVE_TAB	Additional save for GUD blocks
18118 [1)]	MM_NUM_GUD_MODULES	Number of GUD files in the active file system
18120 [1)]	MM_NUM_GUD_NAMES_NCK	Number of global GUD names
18130 [1)]	MM_NUM_GUD_NAMES_CHAN	Number of channel-spec. GUD names
18140 [1)]	MM_NUM_GUD_NAMES_AXIS	Number of axis-spec. GUD names
18150 [1)]	MM_GUD_VALUES_MEM	Memory location for global GUD values
18660 [1)]	MM_NUM_SYNACT_GUD_REAL	Number of configurable GUD of the REAL data type
18661 [1)]	MM_NUM_SYNACT_GUD_INT	Number of configurable GUD of the INT data type
18662 [1)]	MM_NUM_SYNACT_GUD_BOOL	Number of configurable GUD of the BOOL data type
18663 [1)]	MM_NUM_SYNACT_GUD_AXIS	Number of configurable GUD of the AXIS data type
18664 [1)]	MM_NUM_SYNACT_GUD_CHAR	Number of configurable GUD of the CHAR data type
18665 [1)]	MM_NUM_SYNACT_GUD_STRING	Number of configurable GUD of the STRING data type

[1)] For SINUMERIK 828D, MD can only be read!

Program-global user variables (PUD)

Note

Visibility of program-global user variables (PUD)

Program-global user variables (PUD) defined in the main program will only be visible in subprograms if the following machine data is set:

MD11120 $MN_LUD_EXTENDED_SCOPE = 1

If MD11120 = 0 the program-global user variables defined in the main program will only be visible in the main program.

Cross-channel use of an NCK-global user variable of the AXIS data type

An NCK-global user variable of the `AXIS` data type initialized during definition in the data block with an axis identifier can then only be used in other NC channels if the axis has the same channel axis number in these channels.

If this is not the case, the variable has to be loaded at the start of the part program or, as in the following example, the AXNAME(...) function has to be used.

Program code	Comment
`DEF NCK STRING[5] ACHSE="X"`	`;Definition in the data block`
`...`	
`N100 AX[AXNAME(ACHSE)]=111 G00`	`;Use in the part program`

1.1.5 Redefinition of system variables, user variables, and NC language commands (REDEF)

Function

The `REDEF` command can be used to change the attributes of system variables, user variables and NC language commands. A fundamental condition of redefinition is that it has to post-date the corresponding definition.

Multiple attributes cannot be changed simultaneously during redefinition. A separate `REDEF` statement has to be programmed for each attribute to be changed.

If two or more concurrent attribute changes are programmed, the last change is always active.

Resetting attribute values

The attributes for access rights and initialization time change with REDEF can be reset to their default values by reprogramming REDEF, followed by the name of the variable or the NC language command:

- Access rights: Protection level 7
- Initialization time: No initialization or retention of the current value

Redefinable attributes

See "Overview of definable and redefinable attributes (Page 44)"

Local user variables (PUD/LUD)

Redefinitions are not permitted for local user variables (PUD/LUD).

Syntax

```
REDEF <name> <PP_stop>
REDEF <name> <phys_unit>
REDEF <name> <limit_values>
REDEF <name> <access_rights>
REDEF <name> <init_time>
REDEF <name> <init_time> <init_value>
REDEF <name>
```

Meaning

REDEF:	Command for redefinition of a certain attribute or to reset the "Access rights" and/or "Initialization time" attributes of system variables, user variables and NC language commands
<name>:	Name of an already defined variable or an NC language command
<PP stop>:	Preprocessing stop SYNR: Preprocessing stop when reading SYNW: Preprocessing stop when writing SYNRW: Preprocessing stop when reading/writing
<phys_unit>:	Physical unit PHU <unit>: Physical unit See "Attribute: Physical unit (PHU) (Page 37)" **Note** Cannot be redefined for: • System variables • Global user data (GUD) of the data types: BOOL, AXIS, STRING, FRAME

<limit values>: Lower/upper limit

LLI <limit value>: Lower limit value (lower limit)

ULI <limit value>: Upper limit value (upper limit)

See "Attribute: Limit values (LLI, ULI) (Page 35)"

Note

Cannot be redefined for:

- System variables
- Global user data (GUD) of the data types: BOOL, AXIS, STRING, FRAME

<access rights>: Access rights for reading/writing via part program or OPI

APX <protection level>: Execute: NC language element

APRP <protection level>: Read: Part program

APWP <protection level>: Write: Part program

APRB <protection level>: Read: OPI

APWB <protection level>: Write: OPI

<protection level>: Range of values: 0 ... 7

See "Attribute: Access rights (APR, APW, APRP, APWP, APRB, APWB) (Page 39)"

<init_time>: Point in time at which the variable is reinitialized

INIPO: Power On

INIRE: End of main program, NC reset or Power On

INICF: NewConfig or end of main program, NC reset or Power On

PRLOC: End of main program, NC reset following local change or Power On

See "Attribute: Initialization value (Page 32)"

<init_value>: Initialization value

When redefining the initialization value, an initialization time always has to be specified also (see <init_time>).

See "Attribute: Initialization value (Page 32)"

For the Initialization of array variables see "Definition and initialization of array variables (DEF, SET, REP) (Page 45)"

Note

Cannot be redefined for system variables, except setting data.

Example

Redefinitions of system variable $TC_DPC1 in the data block for machine manufacturers

Program code

```
%_N_MGUD_DEF                                          ; GUD block: Machine manufacturer
N100 REDEF $TC_DPC1 APWB 2 APWP 3
N200 REDEF $TC_DPC2 PHU 21
N300 REDEF $TC_DPC3 LLI 0 ULI 200
N400 REDEF $TC_DPC4 INIPO (100, 101, 102, 103)
; N100: Write access: OPI = protection level 2, part program = protection level 3
; Note
; When using ACCESS files the redefinition of access rights has to be moved from
; _N_MGUD_DEF to _N_MACCESS_DEF
; N200: Physical unit = [ % ]
; N300: Limit values: Lower limit value = 0, upper limit value = 200
; N400: The array variable is initialized with the four values at POWER ON.
; Reset of the "Access rights" and/or "Initialization time" attribute values
N800 REDEF $TC_DPC1
N900 REDEF $TC_DPC4
M30
```

Supplementary conditions

Granularity

A redefinition is always applied to the entire variable which is uniquely identified by its name. Array variables do not, for example, support the assignment of different attributes to individual array elements.

1.1.6 Attribute: Initialization value

Definition (DEF) of user variables

During definition an initialization value can be preassigned for the following user variables:

- Global user variables (GUD)
- Program-global user variables (PUD)
- Local user variables (LUD)

Redefinition (REDEF) of system and user variables

During redefinition an initialization value can be preassigned for the following variables:

- System data
  - Setting data
- User data
  - R parameters
  - Synchronized action variables ($AC_MARKER, $AC_PARAM, $AC_TIMER)
  - Synchronized action GUD (SYG_xy[ ], where x=R, I, B, A, C, S and y=S, M, U, 4 to 9)
  - EPS parameters
  - Tool data OEM
  - Magazine data OEM
  - Global user variables (GUD)

Reinitialization time

During redefinition the point in time can be specified at which the variable should be reinitialized, i.e. reset to the initialization value.

- INIPO (POWER ON)

  The variable is reinitialized at Power On.

- INIRE (reset)

  The variable is reinitialized on NC reset, mode group reset, at the end of the part program (M02/M30) or at Power On.

- INICF (NewConfig)

  The variable is reinitialized on a NewConf request via the HMI, with part program command NEWCONFIG or on an NC reset, mode group reset, at the end of the part program (M02/M30) or at Power On.

- PRLOC (program-local change)

  The variable is only reinitialized on an NC reset, mode group reset or at the end of the part program (M02/M30) if it has changed during the current part program.

  The PRLOC attribute may only be changed in conjunction with programmable setting data (see the table below).

Table 1- 1 Programmable setting data

Number	Identifier	G command 1)
42000	$SC_THREAD_START_ANGLE	SF
42010	$SC_THREAD_RAMP_DISP	DITS/DITE
42400	$SA_PUNCH_DWELLTIME	PDELAYON
42800	$SA_SPIND_ASSIGN_TAB	SETMS
43210	$SA_SPIND_MIN_VELO_G25	G25
43220	$SA_SPIND_MAX_VELO_G26	G26
43230	$SA_SPIND_MAX_VELO_LIMS	LIMS

Number	Identifier	G command 1)
43300	$SA_ASSIGN_FEED_PER_REV_SOURCE	FPRAON
43420	$SA_WORKAREA_LIMIT_PLUS	G26
43430	$SA_WORKAREA_LIMIT_MINUS	G25
43510	$SA_FIXED_STOP_TORQUE	FXST
43520	$SA_FIXED_STOP_WINDOW	FXSW
43700	$SA_OSCILL_REVERSE_POS1	OSP1
43710	$SA_OSCILL_REVERSE_POS2	OSP2
43720	$SA_OSCILL_DWELL_TIME1	OST1
43730	$SA_OSCILL_DWELL_TIME2	OST2
43740	$SA_OSCILL_VELO	FA
43750	$SA_OSCILL_NUM_SPARK_CYCLES	OSNSC
43760	$SA_OSCILL_END_POS	OSE
43770	$SA_OSCILL_CTRL_MASK	OSCTRL
43780	$SA_OSCILL_IS_ACTIVE	OS
43790	$SA_OSCILL_START_POS	OSB
1) This G command is used to address the setting data.		

Supplementary conditions

Initialization value: Global user variables (GUD)

- Only INIPO (Power On) can be defined as the initialization time for global user variables (GUD) with the NCK range of validity.
- In addition to INIPO (Power On), INIRE (reset) or INICF (NewConfig) can be defined as the initialization time for global user variables (GUD) with the CHAN range of validity.
- In the case of global user variables (GUD) with the CHAN range of validity and INIRE (reset) or INICF (NewConfig) initialization time, for an NC reset, mode group reset and NewConfig, the variables are only reinitialized in the channels in which the named events were triggered.

Initialization value: FRAME data type

It is not permitted to specify an initialization value for variables of the FRAME data type. Variables of the FRAME data type are initialized implicitly and always with the default frame.

Initialization value: CHAR data type

For variables of the CHAR data type, instead of the ASCII code (0...255), the corresponding ASCII character can be programmed in quotation marks, e.g. "A".

Initialization value: STRING data type

In the case of variables of the STRING data type, the character string must be enclosed in quotation marks, e.g. ...= "MACHINE_1"

Initialization value: AXIS data type

In the case of variables of the AXIS data type, for an extended address notation, the axis identifier must be enclosed in brackets, e.g. ...=(X3).

Initialization value: System variable

For system variables, redefinition cannot be used to define user-specific initialization values. The initialization values for the system variables are specified by the system and cannot be changed. However, redefinition can be used to change the point in time (INIRE, INICF) at which the system variable is reinitialized.

Implicit initialization value: AXIS data type

For variables of the AXIS data type the following implicit initialization value is used:

- System data: "First geometry axis"
- Synchronized action GUD (designation: SYG_A*), PUD, LUD:
  Axis identifier from machine data: MD20082 $MC_AXCONF_CHANAX_DEFAULT_NAME

Implicit initialization value: Tool and magazine data

Initialization values for tool and magazine data can be defined using the following machine data: MD17520 $MN_TOOL_DEFAULT_DATA_MASK

Note

Synchronization

The synchronization of events triggering the reinitialization of a global variable when this variable is read in a different location is the sole responsibility of the user/machine manufacturer.

See also

Variables (Page 17)

1.1.7 Attribute: Limit values (LLI, ULI)

An upper and a lower limit of the definition range can only be defined for the following data types:

- INT
- REAL
- CHAR

Definition (DEF) of user variables: Limit values and implicit initialization values

If no explicit initialization value is defined when defining a user variable of one of the above data types, the variable is set to the data type's implicit initialization value.

- INT: 0
- REAL: 0.0
- CHAR: 0

If the implicit initialization value is outside the definition range specified by the programmed limit values, the variable is initialized with the limit value which is closest to the implicit initialization value:

- Implicit initialization value < lower limit value (LLI) ⇒ initialization value = lower limit value
- Implicit initialization value > upper limit value (ULI) ⇒ initialization value = upper limit value

Examples:

```
Program code                Comment
DEF REAL GUD1               ;   Lower limit value = definition range limit
                            ;   Upper limit value = definition range limit
                            ;   No initialization value programmed
                            ;   => Implicit initialization value = 0.0
DEF REAL LLI 5.0 GUD2       ;   Lower limit value = 5.0
                            ;   Upper limit value = definition range limit
                            ;   => Initialization value = 5.0
DEF REAL ULI -5 GUD3        ;   Lower limit value = definition range limit
                            ;   Upper limit value = -5.0
                            ;   => Initialization value = -5.0
```

Redefinition (REDEF) of user variables: Limit values and current actual values

If, when the limit values of a user variable are redefined, they change to the extent that the current actual value is outside the new definition range, an alarm will be issued and the limit values will be rejected.

Note

Redefinition (REDEF) of user variables

When the limit values of a user variable are redefined, care must be taken to ensure that the following values are changed consistently:

- Limit values
- Actual value
- Initialization value on redefinition and automatic reinitialization on the basis of INIPO, INIRE or INICF

See also

Variables (Page 17)

1.1.8 Attribute: Physical unit (PHU)

A physical unit can only be specified for variables of the following data types:

- INT
- REAL

Programmable physical units (PHU)

The physical unit is specified as fixed point number: `PHU <unit>`

The following physical units can be programmed:

<unit>	Meaning	Physical unit
0	Not a physical unit	-
1	Linear or angular position 1)2)	[mm], [inch], [degree]
2	Linear position 2)	[mm], [inch]
3	Angular position	[degree]
4	Linear or angular velocity 1)2)	[mm/min], [inch/min], [rpm]
5	Linear velocity 2)	[mm/min]
6	Angular velocity	[rpm]
7	Linear or angular acceleration 1)2)	[m/s^2], [$inch/s^2$], [rev/s^2]
8	Linear acceleration 2)	[m/s^2], [$inch/s^2$]
9	Angular acceleration	[rev/s^2]
10	Linear or angular jerk 1)2)	[m/s^3], [$inch/s^3$], [rev/s^3]
11	Linear jerk 2)	[m/s^3], [$inch/s^3$]
12	Angular jerk	[rev/s^3]
13	Time	[s]
14	Position controller gain	[16.667/s]
15	Revolutional feedrate 2)	[mm/rev], [inch/rev]
16	Temperature compensation 1)2)	[mm], [inch]
18	Force	[N]
19	Mass	[kg]
20	Moment of inertia 3)	[kgm^2]
21	Percent	[%]
22	Frequency	[Hz]
23	Voltage	[V]
24	Current	[A]
25	Temperature	[°C]
26	Angle	[degree]
27	KV	[1000/min]
28	Linear or angular position 3)	[mm], [inch], [degree]
29	Cutting rate 2)	[m/min], [feet/min]

<unit>	Meaning	Physical unit
30	Peripheral speed 2)	[m/s], [feet/s]
31	Resistance	[ohm]
32	Inductance	[mH]
33	Torque 3)	[Nm]
34	Torque constant 3)	[Nm/A]
35	Current controller gain	[V/A]
36	Speed controller gain 3)	[Nm/(rad*s)]
37	Speed	[rpm]
42	Power	[kW]
43	Current, low	[µA]
46	Torque, low 3)	[µNm]
48	Per mil	-
49	-	[Hz/s]
65	Flow rate	[l/min]
66	Pressure	[bar]
67	Volume 3)	[cm^3]
68	Controlled-system gain 3)	[mm/(V*min)]
69	Force controller controlled-system gain	[N/V]
155	Thread lead 3)	[mm/rev], [inch/rev]
156	Change in thread lead 3)	[mm/rev / rev], [inch/rev / rev]
1) The physical unit depends on the axis type: Linear or rotary axis		
2) System of units changeover G70/G71(inch/metric) After changing over the basic system (MD10240 $MN_SCALING_SYSTEM_IS_METRIC) with G70/G71, for read/write operations to system and user variables involving a length, then the values are **not** converted (actual value, default value and limit values) G700/G710(inch/metric) After changing over the basic system (MD10240 $MN_SCALING_SYSTEM_IS_METRIC) with G700/G710, for read/write operations to system and user variables involving a length, then the values **are** converted (actual value, default value and limit values)		
3) The variable is **not** converted to the NC's current measuring system (inch/metric) automatically. Conversion is the sole responsibility of the user/machine manufacturer.		

Note

Level overflow due to format conversion

The internal storage format for all user variables (GUD/PUD/LUD) with physical units of length is metric. Excessive use of these types of variable in the NCK's main run, e.g in synchronized actions, can lead to a CPU time overflow at interpolation level when the measuring system is switched over, generating alarm 4240.

Note

Compatibility of units

When using variables (assignment, comparison, calculation, etc.) the compatibility of the units involved is not checked. Should conversion be required, this is the sole responsibility of the user/machine manufacturer.

See also

Variables (Page 17)

1.1.9 Attribute: Access rights (APR, APW, APRP, APWP, APRB, APWB)

The following protection levels, which have to be specified during programming, correspond to the access rights:

Access right	Protection level
System password	0
Machine manufacturer password	1
Service password	2
End user password	3
Key-operated switch position 3	4
Key-operated switch position 2	5
Key-operated switch position 1	6
Key-operated switch position 0	7

Definition (DEF) of user variables

Access rights (APR.../APW...) can be defined for the following variables:

- Global user data (GUD)

Redefinition (REDEF) of system and user variables

Access rights (APR.../APW...) can be redefined for the following variables:

- System data
  - Machine data
  - Setting data
  - FRAME
  - Process data
  - Leadscrew error compensation data (LEC)
  - Sag compensation (CEC)
  - Quadrant error compensation (QEC)
  - Magazine data
  - Tool data
  - Protection zones
  - Toolholder with orientation capability
  - Kinematic chains
  - 3D protection zones
  - Working area limitation
  - ISO tool data
- User data
  - R parameters
  - Synchronized action variables ($AC_MARKER, $AC_PARAM, $AC_TIMER)
  - Synchronized action GUD (SYG_xy[ ], where x=R, I, B, A, C, S and y=S, M, U, 4 to 9)
  - EPS parameters
  - Tool data OEM
  - Magazine data OEM
  - Global user variables (GUD)

Note

During redefinition the access right can be freely assigned to a variable between the lowest protection level 7 and the dedicated protection level, e.g. 1 (machine manufacturer).

Redefinition (REDEF) of NC language commands

The access or execution right (APX) can be redefined for the following NC language commands:

- G functions/Preparatory functions

  References:

  Programming Manual, Fundamentals; Section: G functions/Preparatory functions

- Predefined functions

  References:

  Programming Manual, Fundamentals; Section: Predefined functions

- Predefined subprogram calls

  References:

  Programming Manual, Fundamentals; Section: Predefined subprogram calls

- DO operation with synchronized actions
- Cycles program identifier

  The cycle must be saved in a cycle directory and must contain a PROC operation.

Access rights in relation to part programs and cycles (APRP, APWP)

The various access rights facilitate the following with regard to access in a part program or cycle:

- APRP 0/APWP 0
  - During part program processing the system password has to be set.
  - The cycle has to be stored in the _N_CST_DIR directory (system).
  - The execution right must be set to system for the _N_CST_DIR directory in MD11160 $MN_ACCESS_EXEC_CST.
- APRP 1/APWP 1 or APRP 2/APWP 2
  - During part program processing the machine manufacturer or service password has to be set.
  - The cycle has to be stored in the _N_CMA_DIR (machine manufacturer) or _N_CST_DIR (system) directory.
  - The execution rights must be set to at least machine manufacturer for the _N_CMA_DIR or _N_CST_DIR directories in machine data MD11161 $MN_ACCESS_EXEC_CMA or MD11160 $MN_ACCESS_EXEC_CST respectively.

- APRP 3/APWP 3
  - During part program processing the end user password has to be set.
  - The cycle has to be stored in the _N_CUS_DIR (user), _N_CMA_DIR or _N_CST_DIR directory.
  - The execution rights must be set to at least end user for the _N_CUS_DIR, _N_CMA_DIR or _N_CST_DIR directories in machine data MD11162 $MN_ACCESS_EXEC_CUS, MD11161 $MN_ACCESS_EXEC_CMA or MD11160 $MN_ACCESS_EXEC_CST respectively.
- APRP 4...7/APWP 4...7
  - During part program processing the key-operated switch must be set to 3 ... 0.
  - The cycle has to be stored in the _N_CUS_DIR, _N_CMA_DIR or _N_CST_DIR directory.
  - The execution rights must be set to at least the corresponding key-operated switch position for the _N_CUS_DIR, _N_CMA_DIR or _N_CST_DIR directories in machine data MD11162 $MN_ACCESS_EXEC_CUS, MD11161 $MN_ACCESS_EXEC_CMA or MD11160 $MN_ACCESS_EXEC_CST respectively.

Access rights in relation to OPI (APRB, APWB)

The access rights (APRB, APWB) restrict access to system and user variables via the OPI equally for all system components (HMI, PLC, external computers, EPS services, etc.).

Note

Local HMI access rights

When changing access rights to system data, care must be taken to ensure that such changes are consistent with the access rights defined using HMI mechanisms.

APR/APW access attributes

For compatibility reasons, attributes APR and APW are implicitly mapped to the attributes APRP / APRB and APWP / APWB:

- APR x ⇒ APRP x APRB x
- APW y ⇒ APWP y APWB y

Setting access rights using ACCESS files

When using ACCESS files to assign access rights, redefinitions of access rights for system data, user data, and NC language commands may only continue to be programmed in these ACCESS files. Global user data (GUD) is an exception. For this data, access rights have to continue to be redefined (if this appears necessary) in the corresponding definition files.

For continuous access protection, the machine data for the execution rights and the access protection for the corresponding directories have to be modified consistently.

In principle, the procedure is as follows:

- Creation of the necessary definition files:
  - _N_DEF_DIR/_N_SACCESS_DEF
  - _N_DEF_DIR/_N_MACCESS_DEF
  - _N_DEF_DIR/_N_UACCESS_DEF
- Setting of the write right for the definition files to the value required for redefinition:
  - MD11170 $MN_ACCESS_WRITE_SACCESS
  - MD11171 $MN_ACCESS_WRITE_MACCESS
  - MD11172 $MN_ACCESS_WRITE_UACCESS
- For access to protected elements from cycles, the execution and write rights for cycle directories _N_CST_DIR, _N_CMA_DIR, and _N_CST_DIR have to be modified.

  Execution rights
  - MD11160 $MN_ACCESS_EXEC_CST
  - MD11161 $MN_ACCESS_EXEC_CMA
  - MD11162 $MN_ACCESS_EXEC_CUS

  Write rights
  - MD11165 $MN_ACCESS_WRITE_CST
  - MD11166 $MN_ACCESS_WRITE_CMA
  - MD11167 MN_ACCESS_WRITE_CUS

  The execution right has to be set to at least the same protection level as the highest protection level of the element used.

  The write right must be set to at least the same protection level as the execution right.
- The write rights of the local HMI cycle directories must be set to the same protection level as the local NC cycle directories.

  References:

  Operating Manual

Subprogram calls in ACCESS files

To structure access protection further, subprograms (SPF or MPF identifier) can be called in ACCESS files. The subprograms inherit the execution rights of the calling ACCESS file.

Note

Only access rights can be redefined in the ACCESS files. All other attributes have to continue to be programmed/redefined in the corresponding definition files.

See also

Variables (Page 17)

1.1.10 Overview of definable and redefinable attributes

The following tables show which attributes can be defined (DEF) and/or redefined (REDEF) for which data types.

System data

Data type	Init. value	Limit values	Physical unit	Access rights
Machine data	---	---	---	REDEF
Setting data	REDEF	---	---	REDEF
FRAME data	---	---	---	REDEF
Process data	---	---	---	REDEF
Leadscrew error comp. (EEC)	---	---	---	REDEF
Sag compensation (CEC)	---	---	---	REDEF
Quadrant error compensation (QEC)	---	---	---	REDEF
Magazine data	---	---	---	REDEF
Tool data	---	---	---	REDEF
Protection zones	---	---	---	REDEF
Toolholder, with orientation capability	---	---	---	REDEF
Kinematic chains	---	---	---	REDEF
3D protection zones	---	---	---	REDEF
Working area limitation	---	---	---	REDEF
ISO tool data	---	---	---	REDEF

User data

Data type	Init. value	Limit values	Physical unit	Access rights
R-parameters	REDEF	REDEF	REDEF	REDEF
Synchronized action variable ($AC_...)	REDEF	REDEF	REDEF	REDEF
Synchronized action GUD (SYG_...)	REDEF	REDEF	REDEF	REDEF
EPS parameters	REDEF	REDEF	REDEF	REDEF
Tool data OEM	REDEF	REDEF	REDEF	REDEF
Magazine data OEM	REDEF	REDEF	REDEF	REDEF
Global user variables (GUD)	DEF/REDEF	DEF	DEF	DEF/REDEF
Local user variables (PUD/LUD)	DEF	DEF	DEF	---

See also

Variables (Page 17)

1.1.11 Definition and initialization of array variables (DEF, SET, REP)

Function

A user variable can be defined as a 1- up to a maximum of a 3-dimensional array.

- 1-dimensional: `DEF <data type> <variable name>[<n>]`
- 2-dimensional: `DEF <data type> <variable name>[<n>,<m>]`
- 3-dimensional: `DEF <data type> <variable name>[<n>,<m>,<o>]`

Note

STRING data type user variables can be defined as up to a maximum of 2-dimensional arrays.

Data types

User variables can be defined as arrays for the following data types: BOOL, CHAR, INT, REAL, STRING, AXIS, FRAME

Assignment of values to array elements

Values can be assigned to array elements at the following points in time:

- During array definition (initialization values)
- During program execution

Values can be assigned by means of:

- Explicit specification of an array element
- Explicit specification of an array element as a starting element and specification of a value list (SET)
- Explicit specification of an array element as a starting element and specification of a value and the frequency at which it is repeated (REP)

Note

FRAME data type user variables cannot be assigned initialization values.

Syntax (DEF)

```
DEF <data type> <variable name>[<n>,<m>,<o>]
DEF  STRING[<string length>] <variable name>[<n>,<m>]
```

Syntax (DEF...=SET...)

Using a value list:

- During definition:

  ```
  DEF <data type> <variable name>[<n>,<m>,<o>]=SET(<value1>,<value2>, etc.)
  ```

  Equivalent to:

  ```
  DEF <data type> <variable name>[<n>,<m>,<o>]=(<value1>,<value2>, etc.)
  ```

  Note

  SET does not have to be specified for initialization via a value list.

- During value assignment:

  ```
  <variable name>[<n>,<m>,<o>]=SET(<VALUE1>,<value2>, etc.)
  ```

Syntax (DEF...=REP...)

Using a value with repetition

- During definition:

  ```
  DEF <data type> <variable name>[<n>,<m>,<o>]=REP(<value>)


  DEF <data type> <variable name>[<n>,<m>,<o>]=REP(<value>, <number_array_elements>)
  ```

- During value assignment:

  ```
  <variable name>[<n>,<m>,<o>]=REP(<value>)

  DEF <data type> <variable name>[<n>,<m>,<o>]=REP(<value>,<number_array_elements>)
  ```

Meaning

`DEF`:	Command to define variables
`<data type>`:	Data type of variables Range of values: • for system variables: BOOL, CHAR, INT, REAL, STRING, AXIS • for GUD or LUD variables: BOOL, CHAR, INT, REAL, STRING, AXIS, FRAME
`<string length>`:	Maximum number of characters for a STRING data type
`<variable name>`:	Variable name.
`[<n>,<m>,<o>]`:	Array sizes or array indices
`<n>`:	Array size or array index for 1st dimension Type: INT (for system variables, also AXIS) Range of values: Max. array size: 65535 Array index: 0 ≤ n ≤ 65534
`<m>`:	Array size or array index for 2nd dimension Type: INT (for system variables, also AXIS) Range of values: Max. array size: 65535 Array index: 0 ≤ m ≤ 65534
`<o>`:	Array size or array index for 3rd dimension Type: INT (for system variables, also AXIS) Range of values: Max. array size: 65535 Array index: 0 ≤ o ≤ 65534
`SET`:	Value assignment using specified value list
`(<value1>,<value2>, etc.)`:	Value list
`REP`:	Value assignment using specified `<value>`
`<value>`:	Value, which the array elements should be written when initializing with `REP`.
`<number_array_elements>`:	Number of array elements to be written with the specified `<value>`. The following apply to the remaining array elements, dependent on the point in time: • Initialization when defining the array: → Zero is written to the remaining array elements. • Assignment during program execution: → The actual values of the array elements remain unchanged. If the parameter is not programmed, all array elements are written with `<value>`. If the parameter equals zero, the following apply dependent on the point in time: • Initialization when defining the array: → All elements are pre-assigned zero • Assignment during program execution: → The actual values of the array elements remain unchanged.

Array index

The implicit sequence of the array elements, e.g. in the case of value assignment using SET or REP, is right to left due to iteration of the array index.

Example: Initialization of a 3-dimensional array with 24 array elements:

```
DEF INT FELD[2,3,4] = REP(1,24)
  FELD[0,0,0] = 1          1st array element
  FELD[0,0,1] = 1          2nd array element
  FELD[0,0,2] = 1          3rd array element
  FELD[0,0,3] = 1          4th array element
  ...
  FELD[0,1,0] = 1          5th array element
  FELD[0,1,1] = 1          6th array element
  ...
  FELD[0,2,3] = 1          12th array element
  FELD[1,0,0] = 1          13th array element
  FELD[1,0,1] = 1          14th array element
  ...
  FELD[1,2,3] = 1          24th array element
```

corresponding to:

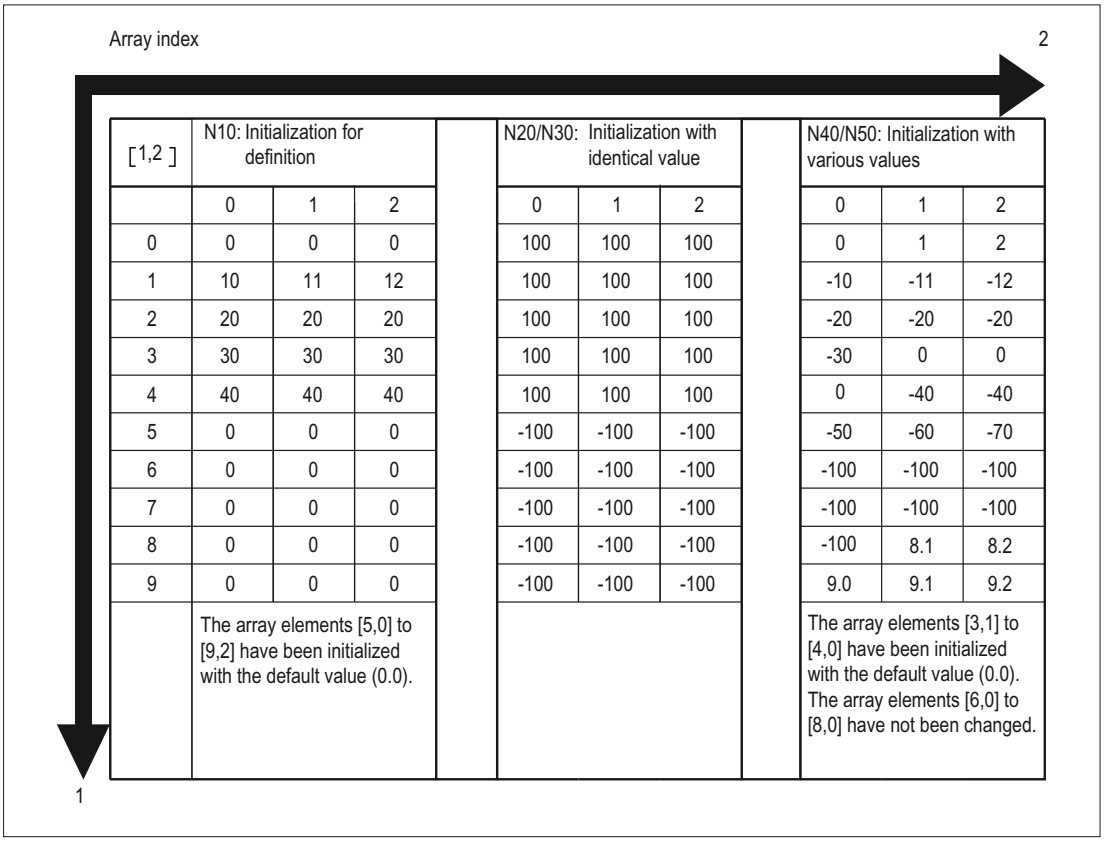
```
FOR n=0 TO 1
  FOR m=0 TO 2
     FOR o=0 TO 3
        FELD[n,m,o] = 1
     ENDFOR
  ENDFOR
ENDFOR
```

Example: Initializing complete variable arrays

For the actual assignment, refer to the diagram.

Program code

```
N10 DEF REAL FELD1[10,3]=SET(0,0,0,10,11,12,20,20,20,30,30,30,40,40,40,)
N20 ARRAY1[0,0] = REP(100)
N30 ARRAY1[5,0] = REP(-100)
N40 FELD1[0,0]=SET(0,1,2,-10,-11,-12,-20,-20,-20,-30, , , ,-40,-40,-50,-60,-70)
N50 FELD1[8,1]=SET(8.1,8.2,9.0,9.1,9.2)
```



[1,2]	N10: Initialization for definition			N20/N30: Initialization with identical value			N40/N50: Initialization with various values		
	0	1	2	0	1	2	0	1	2
0	0	0	0	100	100	100	0	1	2
1	10	11	12	100	100	100	-10	-11	-12
2	20	20	20	100	100	100	-20	-20	-20
3	30	30	30	100	100	100	-30	0	0
4	40	40	40	100	100	100	0	-40	-40
5	0	0	0	-100	-100	-100	-50	-60	-70
6	0	0	0	-100	-100	-100	-100	-100	-100
7	0	0	0	-100	-100	-100	-100	-100	-100
8	0	0	0	-100	-100	-100	-100	8.1	8.2
9	0	0	0	-100	-100	-100	9.0	9.1	9.2
	The array elements [5,0] to [9,2] have been initialized with the default value (0.0).						The array elements [3,1] to [4,0] have been initialized with the default value (0.0). The array elements [6,0] to [8,0] have not been changed.		

See also

Definition and initialization of array variables (DEF, SET, REP): Further Information (Page 49)

Variables (Page 17)

1.1.12 Definition and initialization of array variables (DEF, SET, REP): Further Information

Further information (SET)

initialization during definition

- Starting with the 1st array element, as many array elements are assigned with the values from the value list as there are elements programmed in the value list.
- A value of 0 is assigned to array elements without explicitly declared values in the value list (gaps in the value list).
- For variables of the AXIS data type, gaps in the value list are not permitted.
- If the value list contains more values than there are array elements defined, an alarm will be displayed.

Value assignment in program execution

In the case of value assignment in program execution, the rules described above for definition apply. The following options are also supported:

- Expressions are also permitted as elements in the value list.
- Value assignment starts with the programmed array index. Values can be assigned selectively to subarrays.

Example:

Program code	Comments
`DEF INT ARRAY[5,5]`	`; Array definition`
`ARRAY[0,0]=SET(1,2,3,4,5)`	`; Value assignment to the first 5 array elements [0,0] - [0,4]`
`FELD[0,0]=SET(1,2, , ,5)`	`; Value assignment with gap to the first 5 array elements [0,0] - [0,4], array elements[0,2] and [0,3] = 0`
`ARRAY[2,3]=SET(VARIABLE,4*5.6)`	`; Value assignment with variable and expression starting at array index [2,3]: [2,3] = VARIABLE [2,4] = 4 * 5.6 = 22.4`

Further information (REP)

initialization during definition

- All or the optionally specified number of array elements are initialized with the specified value (constant).
- Variables of the FRAME data type cannot be initialized.

Example:

Program code	Comments
`DEF REAL varName[10]=REP(3.5,4)`	`; Initialize array definition and array elements [0] to [3] with value 3.5.`

Value assignment in program execution

In the case of value assignment in program execution, the rules described above for definition apply. The following options are also supported:

- Expressions are also permitted as elements in the value list.
- Value assignment starts with the programmed array index. Values can be assigned selectively to subarrays.

Examples:

Program code	Comments
`DEF REAL varName[10]`	`; Array definition`
`varName[5]=REP(4.5,3)`	`; Array elements [5] to [7] = 4.5`

```
Program code                              Comments
R10=REP(2.4,3)                            ; R-parameters R10 to R12 = 2.4

DEF FRAME FRM[10]                         ; Array definition
FRM[5] = REP(CTRANS (X,5))                ; Array elements [5] to [9] = CTRANS(X,5)
```

Further information (general)

Value assignments to axial machine data

In principle axial machine data have an array index of the AXIS data type. In the case of value assignments to an axial item of machine data using SET or REP, this array index is ignored or not processed.

Example: Value assignment to machine data MD36200 $MA_AX_VELO_LIMIT

```
$MA_AX_VELO_LIMIT[1,AX1]=SET(1.1, 2.2, 3.3)
```

Is equivalent to:

```
$MA_AX_VELO_LIMIT[1,AX1] = 1.1
$MA_AX_VELO_LIMIT[2,AX1] = 2.2
$MA_AX_VELO_LIMIT[3,AX1] = 3.3
```

Note

Value assignments to axial machine data

In the case of value assignments to axial machine data using SET or REP, the AXIS data type array index is ignored or not processed.

Memory requirements

Data type	Memory requirement per element
BOOL	1 byte
CHAR	1 byte
INT	4 bytes
REAL	8 bytes
STRING	(string length + 1) bytes
FRAME	~ 400 bytes, depending on the number of axes
AXIS	4 bytes

See also

Definition and initialization of array variables (DEF, SET, REP) (Page 45)

1.1.13 Data types

The following data types are available in the NC:

Data type	Significance	Value Range
INT	Integer with sign	-2147483648 ... +2147483647
REAL	Real number (LONG REAL to IEEE)	±(~2.2*10^{-308} … ~1.8*10^{+308})
BOOL	Truth value TRUE (1) and FALSE (0)	1, 0
CHAR	ASCII character	ASCII code 0 to 255
STRING	Character string of a defined length	Maximum of 200 characters (no special characters)
AXIS	Axis/spindle identifier	Channel axis identifier
FRAME	Geometric parameters for static coordinate transformation (translation, rotation, scaling, mirroring)	---

Implicit data type conversions

The following data type conversions are possible and are performed implicitly during assignments and parameter transfers:

from ↓/ to →	REAL	INT	BOOL
REAL	x	o	&
INT	x	x	&
BOOL	x	x	x
x : Possible without restrictions o: Data loss possible due to the range of values being overshot ⇒ alarm; rounding: decimal place value ≥ 0.5 ⇒ round up, decimal place value < 0.5 ⇒ round down &: value ≠ 0 ⇒ TRUE, value== 0 ⇒ FALSE			

See also

Variables (Page 17)

1.1.14 Explicit data type conversions (AXTOINT, INTTOAX)

Function

The data type of an axis variable can be converted explicitly with the predefined functions AXTOINT and INTTOAX.

Type conversion AXIS → INT

Syntax:
```
<result>=AXTOINT(<value>)
```

Meaning:

<result>:	INT representation of the axis variables (≙ axis index <n>)	
	In case of fault	
	= 7	NO_AXIS, i.e. <value> contains the value "no axis"
	= -1	<value> is not an axis name of type AXIS
AXTOINT:	AXTOINT converts the data type of a axis variable from AXIS to INT	
<value>:	Geometry axis name (MD20060 $MC_AXCONF_GEOAX_NAME_TAB[<n>]) or Channel axis name (MD20080 $MC_AXCONF_CHANAX_NAME_TAB[<n>]) or Machine axis name (MD10000 $MN_AXCONF_MACHAX_NAME_TAB[<n>])	
	Data type:	AXIS

Type conversion INT → AXIS

Syntax:
```
<result>=INTTOAX(<value>)
```

<result>:	AXIS representation of the axis variables (≙ axis name)	
	In case of fault	
	= NO_AXIS	<value> contains the value "no axis"?
	= -1	<value> is an INT value for which there is no axis name of type AXIS?
INTTOAX:	INTTOAX converts the data type of a axis variable from INT to AXIS	
<value>:	INT value of the axis variables	
	Range of values:	0 - 32

Example

See example of GETVARDFT at "Read attribute values / data type (GETVARPHU, GETVARAP, GETVARLIM, GETVARDFT, GETVARTYP) (Page 56)".

1.1.15 Check availability of a variable (ISVAR)

Function

The predefined ISVAR function can be used to check whether a system/user variable (e.g. machine data, setting data, system variable, general variables such as GUD) is known in the NCK.

Syntax

```
<Result>=ISVAR(<variable>)
```

The transfer parameter `<variable>` can be set up as follows:

- Undimensioned $ variable: `$<identifier>`
- One-dimensional $ variable without array index: `$<identifier>[ ]`
- One-dimensional $ variable with array index: `$<identifier>[<n>]`
- Two-dimensional $ variable without array index: `$<identifier>[,]`
- Two-dimensional $ variable with array index: `$<identifier>[<n>,<m>]`

Meaning

`<result>`:	Return value		
	Data type:	BOOL	
	Range of values:	1	Variable available
		0	Variable unknown
`ISVAR`:	Checks whether system/user variable is known in the NCK		
`<identifier>`:	Name of the system/user variables		
	Data type:	STRING	
`<n>`:	Array index for first dimension		
	Data type:	INT	
`<m>`:	Array index for second dimension		
	Data type:	INT	

The following checks are made in accordance with the transfer parameter:

- Does the identifier exist
- Is it a 1- or 2-dimensional array
- Is the array index permitted

Only if all these checks have a positive result will TRUE (1) be returned. If a check has a negative result or if a syntax error has occurred, it will return FALSE (0).

Examples

```
Program code                        Comment
DEF INT VAR1
DEF BOOL IS_VAR=FALSE
N10 IS_VAR=ISVAR("VAR1")            ; IS_VAR is in this case TRUE.
```

```
Program code                                    Comment
DEF REAL VARARRAY[10,10]
DEF BOOL IS_VAR=FALSE
N10 IS_VAR=ISVAR("VARARRAY[,]")                 ; IS_VAR is in this case TRUE, is a two-
                                                  dimensional array.
N20 IS_VAR=ISVAR("VARARRAY")                    ; IS_VAR is TRUE, variable exists.
N30 IS_VAR=ISVAR("VARARRAY[8,11]")              ; IS_VAR is FALSE, array index is not
                                                  permitted.
N40 IS_VAR=ISVAR("VARARRAY[8,8")                ; IS_VAR is FALSE, "]" missing (syntax
                                                  error).
N50 IS_VAR=ISVAR("VARARRAY[,8]")                ; IS_VAR is TRUE, array index is
                                                  permitted.
N60 IS_VAR=ISVAR("VARARRAY[8,]")                ; IS_VAR is TRUE, array index is
                                                  permitted.
```

```
Program code                                              Comment
DEF BOOL IS_VAR=FALSE
N100 IS_VAR=ISVAR("$MC_GCODE_RESET_VALUES[1]"             ; Transfer parameter is a
                                                            machine data item, IS_VAR
                                                            is TRUE.
```

```
Program code                        Comment
DEF BOOL IS_VAR=FALSE
N10 IS_VAR=ISVAR("$P_EP")           ; IS_VAR is in this case TRUE.
N20 IS_VAR=ISVAR("$P_EP[X]")        ; IS_VAR is in this case TRUE.
```

1.1.16 Read attribute values / data type (GETVARPHU, GETVARAP, GETVARLIM, GETVARDFT, GETVARTYP)

The attribute values of system/user variables can be read with the predefined GETVARPHU, GETVARAP, GETVARLIM and GETVARDFT functions, the data type of a system/user variable with GETVARTYP.

Read physical unit

Syntax:
`<Result>=GETVARPHU(<name>)`

Meaning:

`<result>`:	Numeric value of the physical unit		
	Data type:	INT	
	Range of values:	See Table in "Attribute: Physical unit (PHU) (Page 37)"	
		In case of fault	
		- 2	The specified `<name>` has not been assigned to a system parameter or a user variable.
`GETVARPHU`:	Reading of the physical unit of a system/user variable		
`<name>`:	Name of the system/user variables		
	Data type:	STRING	

Example:

The NCK contains the following GUD variables:

DEF CHAN REAL PHU 42 LLI 0 ULI 10000 electric

```
Program code                              Comment
DEF INT result=0
result=GETVARPHU("electric")              ; Determine the physical unit of the GUD
                                            variables.
IF (result < 0) GOTOF error
```

The value 42 is returned as result. This corresponds to the physical unit [kW].

Note

GETVARPHU can be used, for example, to check whether both variables have the expected physical units in a variable assignment a = b.

Read access right

Syntax:
<Result>=GETVARAP(<name>,<access>)

Meaning:

<result>:	Protection level for the specified <access>		
	Data type:	INT	
	Range of values:	0 ... 7	See "Attribute: Access rights (APR, APW, APRP, APWP, APRB, APWB) (Page 39)".
		In case of fault	
		- 2	The specified <name> has not been assigned to a system parameter or a user variable.
		- 3	Incorrect value for <access>
GETVARAP:	Reading of the access right to a system/user variable		
<name>:	Name of the system/user variables		
	Data type:	STRING	
<access>:	Type of access		
	Data type:	STRING	
	Range of values:	"RP":	Read via part program
		"WP":	Write via part program
		"RB":	Read via OPI
		"WB":	Write via OPI

Example:

Program code	Comment
DEF INT result=0	
result=GETVARAP("$TC_MAP8","WB")	; Determine the access protection for the system parameter "magazine position" with regard to writing via OPI.
IF (result < 0) GOTOF error	

The value 7 is returned as result. This corresponds to the key switch position 0 (= no access protection).

Note

GETVARAP can be used, for example, to implement a checking program that checks the access rights expected by the application.

Read limit values

Syntax:

```
<Status>=GETVARLIM(<name>,<limit value>,<result>)
```

Meaning:

<Status>:	Function status		
	Data type:	INT	
	Range of values:	1	OK
		-1	No limit value defined (for variables of type AXIS, STRING, FRAME)
		-2	The specified <name> has not been assigned to a system parameter or a user variable.
		-3	Incorrect value for <limit value>
GETVARLIM:	Reading of the lower/upper limit value of a system/user variables		
<name>:	Name of the system/user variables		
	Data type:	STRING	
<limit value>:	specifies which limit value should be read out		
	Data type:	CHAR	
	Range of values:	"L":	= lower limit value
		"U":	= upper limit value
<result>:	Return of the limit value		
	Data type:	VAR REAL	

Example:

```
Program code                                                    Comment
DEF INT state=0
DEF REAL result=0
state=GETVARLIM("$MA_MAX_AX_VELO","L",result)                   ; Determine the lower limit
                                                                  value for MD32000
                                                                  $MA_MAX_AX_VELO.
IF (result < 0) GOTOF error
```

Read default value

Syntax:
`<Status>=GETVARDFT(<name>,<result>[,<index_1>,<index_2>,<index_3>])`

Meaning:

`<Status>`:	Function status		
	Data type:	INT	
	Range of values:	1	OK
		-1	No default value available (e.g. because <result> has the wrong type for <name>)
		-2	The specified `<name>` has not been assigned to a system parameter or a user variable.
		-3	Incorrect value for `<index_1>`, dimension less than one (= no array = scalar)
		-4	Incorrect value for `<index_2>`
		-5	Incorrect value for `<index_3>`
`GETVARDFT`:	Reading of the default value of a system/user variable		
`<name>`:	Name of the system/user variables		
	Data type:	STRING	
`<result>`:	Return of the default value		
	Data type:	VAR REAL (when reading the default value of variables of the types INT, REAL, BOOL, AXIS)	
		VAR STRING (when reading the default value of variables of the types STRING and CHAR)	
		VAR FRAME (when reading the default value of variables of the type FRAME)	
`<index_1>`:	Index to the first dimension (optional)		
	Data type:	INT	
	Not programmed means = 0		
`<index_2>`:	Index to the second dimension (optional)		
	Data type:	INT	
	Not programmed means = 0		
`<index_3>`:	Index to the third dimension (optional)		
	Data type:	INT	
	Not programmed means = 0		

Example:

```
Program code                                                    Comment
DEF INT state=0
DEF REAL resultR=0                                              ; Variable to accept the default
                                                                  values of the types INT, REAL,
                                                                  BOOL, AXIS.
DEF FRAME resultF=0                                             ; Variable to accept the default
                                                                  values of the type FRAME

IF (GETVARTYP("$MA_MAX_AX_VELO") <> 4) GOTOF error
state=GETVARDFT("$MA_MAX_AX_VELO", resultR, AXTOINT(X))         ; Determine the default value of
                                                                  the "X" axis.
                                                                ; AXTOINT converts the axis name
                                                                  "X" to the appropriate access
                                                                  index.
IF (result < 0) GOTOF error

IF (GETVARTYP("$TC_TP8") <> 3) GOTOF error
state=GETVARDFT("$TC_TP8", resultR)

IF (GETVARTYP("$P_UBFR") <> 7) GOTOF error
state=GETVARDFT("$P_UBFR", resultF )
```

Read data type

Syntax:
<Result>=GETVARTYP(<name>)

Meaning:

<result>:	Data type of the specified system/user variables		
	Data type:	INT	
	Range of values:	1	= BOOL
		2	= CHAR
		3	= INT
		4	= REAL
		5	= STRING
		6	= AXIS
		7	= FRAME
		In case of fault	
		< 0	The specified <name> has not been assigned to a system parameter or a user variable.
GETVARTYP:	Reading of the data type of a system/user variable		
<name>:	Name of the system/user variables		
	Data type:	STRING	

Example:

```
Program code                                Comment
DEF INT result=0
DEF STRING name="R"
result=GETVARTYP(name)                      ; Determine the type of the R parameter.
IF (result < 0) GOTOF error
```

The value 4 is returned as result. This corresponds to the REAL data type.

1.2 Indirect programming

1.2.1 Indirectly programming addresses

Function

When indirectly programming addresses, the extended address (<index>) is replaced by a variable with a suitable type.

Note

It is not possible the indirectly program addresses for:

- N (block number)
- L (subprogram)
- Settable addresses
  (e.g. X[1] instead of X1 is not permissible)

Syntax

```
<ADDRESS>[<Index>]
```

Meaning

Element	Description
<ADDRESS>[...]:	Fixed address with extension (index)
<index>:	Variable, e.g. for spindle number, axis, ...

Examples

Example 1: Indirectly programming a spindle number

Direct programming:

```
Program code            Comment
S1=300                  ; Speed in rpm for the spindle number 1.
```

Indirect programming:

```
Program code            Comment
DEF INT SPINU=1         ; Defining variables, type INT and value assignment.
S[SPINU]=300            ; Speed 300 rpm for the spindle, whose number is saved in
                          the SPINU variable (in this example 1, the spindle with
                          the number 1).
```

Example 2: Indirectly programming an axis

Direct programming:

```
Program code            Comment
FA[U]=300               ; Feed rate 300 for axis "U".
```

Indirect programming:

```
Program code            Comment
DEF AXIS AXVAR2=U       ; Defining a variable, type AXIS and value assignment.
FA[AXVAR2]=300          ; Feed rate of 300 for the axis whose address name is saved
                          in the variables with the name AXVAR2.
```

Example 3: Indirectly programming an axis

Direct programming:

```
Program code            Comment
$AA_MM[X]               ; Read probe measured value (MCS) of axis "X".
```

Indirect programming:

```
Program code            Comment
DEF AXIS AXVAR3=X       ; Defining a variable, type AXIS and value assignment.
$AA_MM[AXVAR3]          ; Read probe measured value (MCS) whose name is saved in the
                          variables AXVAR3.
```

Example 4: Indirectly programming an axis

Direct programming:

```
Program code
X1=100 X2=200
```

Indirect programming:

```
Program code                          Comment
DEF AXIS AXVAR1 AXVAR2                ; Defining two type AXIS variables.
AXVAR1=(X1) AXVAR2=(X2)               ; Assigning the axis names.
AX[AXVAR1]=100 AX[AXVAR2]=200         ; Traversing the axes whose address names are
                                        saved in the variables with the names
                                        AXVAR1 and AXVAR2
```

Example 5: Indirectly programming an axis

Direct programming:

```
Program code
G2 X100 I20
```

Indirect programming:

```
Program code                          Comment
DEF AXIS AXVAR1=X                     ; Defining a variable, type AXIS and value
                                        assignment.
G2 X100 IP[AXVAR1]=20                 ; Indirect programming the center point data for
                                        the axis, whose address name is saved in the
                                        variable with the name AXVAR1.
```

Example 6: Indirectly programming array elements

Direct programming:

```
Program code                          Comment
DEF INT ARRAY1[4,5]                   ; Defining array 1
```

Indirect programming:

```
Program code                          Comment
DEFINE DIM1 AS 4                      ; For array dimensions, array sizes must be
                                        specified as fixed values.
DEFINE DIM2 AS 5
DEF INT ARRAY[DIM1,DIM2]
ARRAY[DIM1-1,DIM2-1]=5
```

Example 7: Indirect subprogram call

Program code	Comment
`CALL "L" << R10`	`; Call the program, whose number is located in R10 (string cascading).`

1.2.2 Indirectly programming G codes

Function

Indirect programming of G codes permits cycles to be effectively programmed.

Syntax

`G[<group>]=<number>`

Meaning

`G[...]`:	G command with extension (index)
`<group>`:	Index parameter: G function group Type: INT
`<number>`:	Variable for the G code number Type: INT or REAL

Note

Generally, only G codes that do not determine the syntax can be indirectly programmed.

Only G function group 1 is possible from the G codes that determine the syntax.
The syntax-determining G codes of G function groups 2, 3 and 4 are not possible.

Note

Arithmetic functions are not permitted in the indirect G code programming. If it is necessary to calculate the G code number, this must be done in a separate part program line before the indirect G code programming.

Examples

Example 1: Settable zero offset (G function group 8)

```
Program code                                Comment
N1010 DEF INT INT_VAR
N1020 INT_VAR=2
...
N1090 G[8]=INT_VAR G1 X0 Y0                 ; G54
N1100 INT_VAR=INT_VAR+1                     ; G code calculation
N1110 G[8]=INT_VAR G1 X0 Y0                 ; G55
```

Example 2: Level selection (G function group 6)

```
Program code                                Comment
N2010 R10=$P_GG[6]                          ; read active G function of G function
                                              group 6
...
N2090 G[6]=R10
```

References

For information on the G function groups, see:
Programming Manual, Fundamentals; Section "G function groups"

1.2.3 Indirectly programming position attributes (GP)

Function

Position attributes, e.g. the incremental or absolute programming of the axis position, can be indirectly programmed as variables in conjunction with the key word GP.

Application

The indirect programming of position attributes is used in **replacement cycles**, as in this case, the following advantage exists over programming position attributes as keyword (e.g. IC, AC, ...):

As a result of the indirect programming as variable, **no** CASE instruction is required, which would otherwise branch for all possible position attributes.

Syntax

```
<POSITIONING COMMAND>[<axis/spindle>]=
GP(<position>,<position attribute)
<axis/spindle>=BP(<position>,<position attribute)
```

Meaning

<POSITIONING COMMAND>[]:	The following positioning commands can be programmed together with the key word GP: POS, POSA, SPOS, SPOSA Also possible: • All axis and spindle identifiers present in the channel: <axis/spindle> • Variable axis/spindle identifier AX
<axis/spindle>:	Axis/spindle that is to be positioned
GP():	Key word for positioning
<position>:	Parameter 1 Axis/spindle position as constant or variable
<position attribute>:	Parameter 2 Position attribute (e.g. position approach mode as a variable (e.g. $P_SUB_SPOSMODE) or as key word (IC, AC, ...)

The values supplied from the variables have the following significance:

Value	Meaning	Permissible for:
0	No change to the position attribute	
1	AC	POS, POSA, SPOS, SPOSA, AX, axis address
2	IC	POS, POSA, SPOS, SPOSA, AX, axis address
3	DC	POS, POSA, SPOS, SPOSA, AX, axis address
4	ACP	POS, POSA, SPOS, SPOSA, AX, axis address
5	ACN	POS, POSA, SPOS, SPOSA, AX, axis address
6	OC	-
7	PC	-
8	DAC	POS, POSA, AX, axis address
9	DIC	POS, POSA, AX, axis address
10	RAC	POS, POSA, AX, axis address
11	RIC	POS, POSA, AX, axis address
12	CAC	POS, POSA
13	CIC	POS, POSA
14	CDC	POS, POSA
15	CACP	POS, POSA
16	CACN	POS, POSA

Example

For an active synchronous spindle coupling between the leading spindle S1 and the following spindle S2, the following replacement cycle to position the spindle is called using the SPOS command in the main program.

Positioning is realized using the instruction in N2230:
SPOS[1]=GP($P_SUB_SPOSIT,$P_SUB_SPOSMODE)
SPOS[2]=GP($P_SUB_SPOSIT,$P_SUB_SPOSMODE)

The position to be approached is read from the system variable $P_SUB_SPOSIT; the position approach mode is read from the system variable $P_SUB_SPOSMODE.

```
Program code                                                    Comment
N1000 PROC LANG_SUB DISPLOF SBLOF
...
N2100 IF($P_SUB_AXFCT==2)
N2110                                                           ; Replacement of the SPOS / SPOSA / M19
                                                                  command for an active synchronous
                                                                  spindle coupling
N2185 DELAYFSTON                                                ; Start of Stop delay area
N2190 COUPOF(S2,S1)                                             ; Deactivate synchronous spindle
                                                                  coupling
N2200                                                           ; Position leading and following spindle
N2210 IF($P_SUB_SPOS==TRUE) OR ($P_SUB_SPOSA==TRUE)
N2220                                                           ; Positioning the spindle with SPOS:
N2230    SPOS[1]=GP($P_SUB_SPOSIT,$P_SUB_SPOSMODE)
         SPOS[2]=GP($P_SUB_SPOSIT,$P_SUB_SPOSMODE)
N2250 ELSE
N2260                                                           ; Positioning the spindle using M19:
N2270 M1=19 M2=19                                               ; Position leading and following spindle
N2280 ENDIF
N2285 DELAYFSTOF                                                ; End of Stop delay area
N2290 COUPON(S2,S1)                                             ; Activate synchronous spindle coupling
N2410 ELSE
N2420                                                           ; Query on further replacements
...
N3300 ENDIF
...
N9999 RET
```

Supplementary conditions

- The indirect programming of position attributes is not possible in synchronized actions.

References

Function Manual Basic Functions; BAG, Channel, Program Operation, Reset Response (K1), Section: Replacement of NC functions by subprograms

1.2.4 Indirectly programming part program lines (EXECSTRING)

Function

Using the part program command EXECSTRING, it is possible to execute a previously generated string variable as part program line.

Syntax

EXECSTRING is programmed in a separate part program line:
EXECSTRING (<string_variable>)

Meaning

EXECSTRING:	Command to execute a string variable as part program line
<string variable>:	Type STRING variable, that includes the actual part program line to be executed

Note

With EXECSTRING all part program constructions that can be programmed in the program section of a part program can be extracted. This means that PROC and DEF instructions are excluded as well as the general use in INI and DEF files.

Example

```
Program code                                  Comment
N100 DEF STRING[100] BLOCK                    ; Definition of string variables to
                                                accept the part program line to be
                                                executed.
N110 DEF STRING[10] MFCT1="M7"
...
N200 EXECSTRING(MFCT1 << "M4711")             ; Execute part program line "M7 M4711".
...
N300 R10=1
N310 BLOCK="M3"
N320 IF(R10)
N330 BLOCK = BLOCK << MFCT1
N340 ENDIF
N350 EXECSTRING(BLOCK)                        ; Execute part program line "M3 M7".
```

1.3 Arithmetic functions

Function

The arithmetic functions are primarily for R parameters and variables (or constants and functions) of type REAL. The types INT and CHAR are also permitted.

Operator / arithmetic function	Meaning
+	Addition
-	Subtraction
*	Multiplication
/	Division **Notice**: (type INT)/(type INT)=(type REAL); example: 3/4 = 0.75
DIV	Division, for variable type INT and REAL **Notice**: (type INT)DIV(type INT)=(type INT); example: 3 DIV 4 = 0
MOD	Modulo division (only for type INT) supplies remainder of an INT division Example: 3 MOD 4 = 3
:	Chain operator (for FRAME variables)
Sin()	Sine
COS()	Cosine
TAN()	Tangent
ASIN()	Arc sine
ACOS()	Arc cosine
ATAN2(,)	Arc tangent 2
SQRT()	Square root
ABS()	Absolute value
POT()	2nd power (square)
TRUNC()	Integer component The accuracy for comparison commands can be set using TRUNC (see "Precision correction on comparison errors (TRUNC) (Page 73)")
ROUND()	Round to integer
LN()	Natural logarithm
EXP()	Exponential function
MINVAL ()	Lower value of two variables (see "Variable minimum, maximum and range (MINVAL, MAXVAL and BOUND) (Page 74)")
MAXVAL ()	Larger value of two variables (see "Variable minimum, maximum and range (MINVAL, MAXVAL and BOUND) (Page 74)")

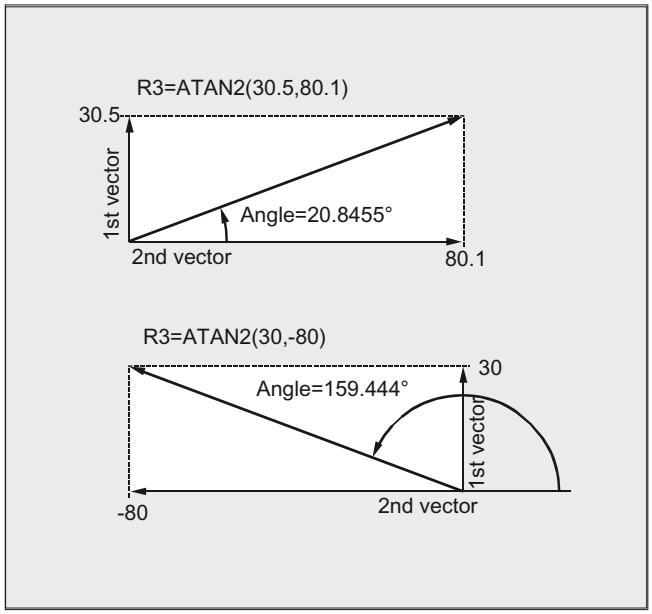
`BOUND ()`	Variable value within the defined value range (see "Variable minimum, maximum and range (MINVAL, MAXVAL and BOUND) (Page 74)")
`CTRANS()`	Offset
`CROT ()`	Rotation
`CSCALE()`	Change of scale
`CMIRROR()`	Mirroring

Programming

The usual mathematical notation is used for arithmetic functions. Priorities for execution are indicated by parentheses. Angles are specified for trigonometry functions and their inverse functions (right angle = 90°).

Examples

Example 1: ATAN2



The arithmetic function ATAN2 calculates the angle of the total vector from two mutually perpendicular vectors.

The result is in one of four quadrants (-180° < 0 < +180°).

The angular reference is always based on the 2nd value in the positive direction.

Example 2: Initializing complete variable arrays

```
Program code                          Comment
R1=R1+1                               ; New R1 = old R1 +1
R1=R2+R3 R4=R5-R6 R7=R8*R9
R10=R11/R12 R13=SIN(25.3)
R14=R1*R2+R3                          ; Multiplication or division takes precedence
                                        over addition or subtraction.
```

Program code	Comment
R14=(R1+R2)*R3	; Parentheses are calculated first.
R15=SQRT(POT(R1)+POT(R2))	; Inner parentheses are resolved first: R15 = square root of (R1+R2)
RESFRAME=FRAME1:FRAME2 FRAME3=CTRANS(…):CROT(…)	; The concatenation operator links frames to form a resulting frame or assigns values to frame components.

1.4 Comparison and logic operations

Function

Comparison operations can be used, for example, to formulate a jump condition. Complex expressions can also be compared.

The comparison operations are applicable to variables of type CHAR, INT, REAL and BOOL. The code value is compared with the CHAR type.
For types STRING, AXIS and FRAME, the following are possible: == and <>, which can be used for STRING type operations, even in synchronous actions.

The result of comparison operations is always of BOOL type.

Logic operators are used to link truth values.

The logical operations can only be applied to type BOOL variables. However, they can also be applied to the CHAR, INT and REAL data types via internal type conversion.

For the logic (Boolean) operations, the following applies to the BOOL, CHAR, INT and REAL data types:

- 0 corresponds to: FALSE
- Not equal to 0 means: TRUE

Bit-by-bit logic operators

Logic operations can also be applied to single bits of types CHAR and INT. Type conversion is automatic.

Programming

Relational operator	Meaning
==	Equal to
<>	Not equal to
>	Greater than
<	Less than
>=	Greater than or equal to
<=	Less than or equal to

Logic operator	Meaning
AND	AND
OR	OR
NOT	Negation
XOR	Exclusive OR

Bit-by-bit logic operator	Meaning
B_AND	Bit-by-bit AND
B_OR	Bit-by-bit OR
B_NOT	Bit-by-bit negation
B_XOR	Bit-by-bit exclusive OR

Note

In arithmetic expressions, the execution order of all the operators can be specified by parentheses, in order to override the normal priority rules.

Note

Spaces must be left between BOOLEAN operands and operators.

Note

The operator `B_NOT` only refers to one operand. This is located after the operator.

Examples

Example 1: Comparison operators

```
IF R10>=100 GOTOF DEST
```

or

```
R11=R10>=100
IF R11 GOTOF DEST
```

The result of the `R10>=100` comparison is first buffered in `R11`.

Example 2: Logic operators

```
IF (R10<50) AND ($AA_IM[X]>=17.5) GOTOF DESTINATION
```

or

```
IF NOT R10 GOTOB START
```

`NOT` only refers to one operand.

Example 3: Bit-by-bit logic operators

```
IF $MC_RESET_MODE_MASK B_AND 'B10000' GOTOF  ACT_PLANE
```

1.5 Precision correction on comparison errors (TRUNC)

Function

The TRUNC command truncates the operand multiplied by a precision factor.

Settable precision for comparison commands

Program data of type REAL are displayed internally with 64 bits in IEEE format. This display format can cause decimal numbers to be displayed imprecisely and lead to unexpected results when compared with the ideally calculated values.

Relative equality

To prevent the imprecision caused by the display format from interfering with program flow, the comparison commands do not check for absolute equality but for relative equality.

Syntax

Precision correction on comparison errors

```
TRUNC (R1*1000)
```

Significance

`TRUNC`: Truncate decimal places

Relative quality of 10^{-12} taken into account for

- Equality: (==)
- Inequality: (<>)
- Greater than or equal to: (>=)
- Less than or equal to: (<=)
- Greater/less than: (><) with absolute equality
- Greater than: (>)
- Less than: (<)

Compatibility

For compatibility reasons, the check for relative quality for (>) and (<) can be deactivated by setting machine data MD10280 $MN_ PROG_FUNCTION_MASK Bit0 = 1.

Note

Comparisons with data of type REAL are subject to a certain imprecision for the above reasons. If deviations are unacceptable, use INTEGER calculation by multiplying the operands by a precision factor and then truncating with TRUNC.

Synchronized actions

The response described for the comparison commands also applies to synchronized actions.

Examples

Example 1: Precision considerations

Program code	Comments
N40 R1=61.01 R2=61.02 R3=0.01	; Assignment of initial values
N41 IF ABS(R2-R1) > R3 GOTOF ERROR	; Jump would have been executed up until now
N42 M30	; End of program
N43 ERROR: SETAL(66000)	;
R1=61.01 R2=61.02 R3=0.01	; Assignment of initial values
R11=TRUNC(R1*1000) R12=TRUNC(R2*1000) R13=TRUNC(R3*1000)	; Accuracy correction
IF ABS(R12-R11) > R13 GOTOF ERROR	; Jump is no longer executed
M30	; End of program
ERROR: SETAL(66000)	;

Example 2: Calculate and evaluate the quotient of both operands

Program code	Comments
R1=61.01 R2=61.02 R3=0.01	; Assignment of initial values
IF ABS((R2-R1)/R3)-1) > 10EX-5 GOTOF ERROR	; Jump is not executed
M30	; End of program
ERROR: SETAL(66000)	;

1.6 Variable minimum, maximum and range (MINVAL, MAXVAL and BOUND)

Function

The MINVAL and MAXVAL commands can be used to compare the values of two variables. The smaller value (in the case of MINVAL) or the larger value (in the case of MAXVAL) respectively is delivered as a result.

The BOUND command can be used to test whether the value of a test variable falls within a defined range of values.

Syntax

```
<smaller value>=MINVAL(<variable1>,<variable2>)
<larger value>=MAXVAL(<variable1>,<variable2>)
<return value>=<BOUND>(<minimum>,<maximum>,<test variable>)
```

Meaning

MINVAL:	Obtains the **smaller** value of two variables (<variable1>, <variable2>)
<smaller value>:	Result variable for the MINVAL command Set to the smaller variable value.
MAXVAL:	Obtains the **larger** value of two variables (<variable1>, <variable2>)
<larger value>:	Result variable for the MAXVAL command Set to the larger variable value.
BOUND:	Tests whether a variable (<test variable) is within a defined range of values.
<minimum>:	Variable which defines the minimum value of the range of values.
<maximum>:	Variable which defines the maximum value of the range of values.
<return value>:	Result variable for the BOUND command If the value of the test variable is within the defined range of values, the result variable is set to the value of the test variable. If the value of the test variable is greater than the maximum value, the result variable is set to the maximum value of the definition range. If the value of the test variable is less than the minimum value, the result variable is set to the minimum value of the definition range.

Note

MINVAL, MAXVAL, and BOUND can also be programmed in synchronized actions.

Note

Behavior if values are equal

If the values are equal MINVAL/MAXVAL are set to this equal value. In the case of BOUND the value of the variable to be tested is returned again.

Example

```
Program code                                        Comment
DEF REAL rVar1=10.5, rVar2=33.7, rVar3, rVar4, rVar5, rValMin, rValMax, rRetVar
rValMin=MINVAL(rVar1,rVar2)                         ; rValMin is set to value 10.5.
rValMax=MAXVAL(rVar1,rVar2)                         ; rValMax is set to value 33.7.
rVar3=19.7
rRetVar=BOUND(rVar1,rVar2,rVar3)                    ; rVar3 is within the limits, rRetVar is set to 19.7.
```

```
Program code                                    Comment
rVar3=1.8
rRetVar=BOUND(rVar1,rVar2,rVar3)                ; rVar3 is below the minimum limit, rRetVar is set to
                                                  10.5.


rVar3=45.2
rRetVar=BOUND(rVar1,rVar2,rVar3)                ; rVar3 is above the maximum limit, rRetVar is set to
                                                  33.7.
```

1.7 Priority of the operations

Function

Each operator is assigned a priority. When an expression is evaluated, the operators with the highest priority are always applied first. Where operators have the same priority, the evaluation is from left to right.

In arithmetic expressions, the execution order of all the operators can be specified by parentheses, in order to override the normal priority rules.

Order of operators

From the highest to lowest priority

1.	NOT, B_NOT	Negation, bit-by-bit negation
2.	*, /, DIV, MOD	Multiplication, division
3.	+, –	Addition, subtraction
4.	B_AND	Bit-by-bit AND
5.	B_XOR	Bit-by-bit exclusive OR
6.	B_OR	Bit-by-bit OR
7.	AND	AND
8.	XOR	Exclusive OR
9.	OR	OR
10.	<<	Concatenation of strings, result type STRING
11.	==, <>, >, <, >=, <=	Comparison operators

Note

The concatenation operator ":" for Frames must not be used in the same expression as other operators. A priority level is therefore not required for this operator.

Example: IF statement

```
If (otto==10) and (anna==20) gotof end
```

1.8 Possible type conversions

Function

Type conversion on assignment

The constant numeric value, the variable, or the expression assigned to a variable must be compatible with the variable type. If this is this case, the type is automatically converted when the value is assigned.

Possible type conversions

to	REAL	INT	BOOL	CHAR	STRING	AXIS	FRAME
from							
REAL	yes	yes*	Yes[1])	yes*	–	–	–
INT	yes	yes	Yes[1])	Yes [2)]	–	–	–
BOOL	yes	yes	yes	yes	yes	–	–
CHAR	yes	yes	Yes [1)]	yes	yes	–	–
STRING	–	–	Yes [4)]	Yes [3)]	yes	–	–
AXIS	–	–	–	–	–	yes	–
FRAME	–	–	–	–	–	–	yes

Explanation

* At type conversion from REAL to INT, fractional values that are >=0.5 are rounded up, others are rounded down (cf. ROUND function).

1) Value <> 0 is equivalent to TRUE; value == 0 is equivalent to FALSE

2) If the value is in the permissible range

3) If only 1 character

4) String length 0 = >FALSE, otherwise TRUE

Note

If conversion produces a value greater than the target range, an error message is output.

If mixed types occur in an expression, type conversion is automatic. Type conversions are also possible in synchronous actions, see Chapter "Motion-synchronous actions, implicit type conversion".

1.9 String operations

Sting operations

In addition to the classic operations "assign" and "comparison" the following string operations are possible:

- Type conversion to STRING (AXSTRING) (Page 78)
- Type conversion from STRING (NUMBER, ISNUMBER, AXNAME) (Page 79)
- Concatenation of strings (<<) (Page 81)
- Conversion to lower/upper case letters (TOLOWER, TOUPPER) (Page 82)
- Determine length of string (STRLEN) (Page 83)
- Search for character/string in the string (INDEX, RINDEX, MINDEX, MATCH) (Page 83)
- Selection of a substring (SUBSTR) (Page 85)
- Reading and writing of individual characters (Page 85)
- Formatting a string (SPRINT) (Page 87)

Special significance of the 0 character

Internally, the 0 character is interpreted as the end identifier of a string. If a character is replaced with the 0 character, the string is truncated.

Example:

```
Program code                                    Comment
DEF STRING[20] STRG="axis . stationary"
STRG[6]="X"
MSG(STRG)                                       ; Supplies the message "axis X
                                                  stationary".
STRG[6]=0
MSG(STRG)                                       ; Supplies the message "axis".
```

1.9.1 Type conversion to STRING (AXSTRING)

Function

Using the function "type conversion to STRING" variables of different types can be used as a component of a message (MSG).

When using the << operator this is realized implicitly for data types INT, REAL, CHAR and BOOL (see "Concatenation of strings (<<) (Page 81)")..

An INT value is converted to normal readable format. REAL values convert with up to 10 decimal places.

Type AXIS variables can be converted to STRING using the `AXSTRING` command.

Syntax

```
<STRING_ERG> = << <any_type>
<STRING_ERG> = AXSTRING(<axis identifier>)
```

Significance

<STRING_ERG>:	Variable for the result of the type conversion Type: STRING
<any_type>:	Variable types INT, REAL, CHAR, STRING and BOOL
AXSTRING:	The AXSTRING command supplies the specified axis identifier as string.
<axis identifier>:	Variable for axis identifier Type: AXIS

Note

FRAME variables cannot be converted.

Examples

Example 1:

```
MSG("Position:"<<$AA_IM[X])
```

Example 2: AXSTRING

Program code	Comments
DEF STRING[32] STRING_ERG	
STRING_ERG=AXSTRING(X)	; STRING_ERG == "X"

1.9.2 Type conversion from STRING (NUMBER, ISNUMBER, AXNAME)

Function

A conversion is made from STRING to REAL using the NUMBER command. The ability to be converted can be checked using the ISNUMBER command.

A string is converted into the axis data type using the AXNAME command.

Syntax

```
<REAL_ERG>=NUMBER("<string>")
<BOOL_ERG>=ISNUMBER("<string>")
<AXIS_ERG>=AXNAME("<string>")
```

Meaning

NUMBER:	The NUMBER command returns the number represented by the <string> as REAL value.		
<string>:	Type STRING variable to be converted		
<REAL_ERG>:	Variable for the result of the type conversion with NUMBER		
	Type: REAL		
ISNUMBER:	The ISNUMBER command can be used to check whether the <string> can be converted into a valid number.		
<BOOL_ERG>:	Variable for the result of the interrogation with ISNUMBER		
	Type: BOOL		
	Value: TRUE	ISNUMBER supplies the value TRUE, if the <string> represents a valid REAL number in compliance with the language rules.	
	FALSE	If ISNUMBER supplies the value FALSE, when calling NUMBER with the same <string>, an alarm is initiated.	
AXNAME:	The AXNAME command converts the specified <string> into an axis identifier.		
	Note: If the <string> cannot be assigned a configured axis identifier, an alarm is initiated.		
<AXIS_ERG>:	Variable for the result of the type conversion with AXNAME		
	Type: AXIS		

Example

```
Program code                                    Comment
DEF BOOL BOOL_ERG
DEF REAL REAL_ERG
DEF AXIS AXIS_ERG
BOOL_ERG=ISNUMBER("1234.9876Ex-7")              ; BOOL_ERG == TRUE
BOOL_ERG=ISNUMBER("1234XYZ")                    ; BOOL_ERG == FALSE
REAL_ERG=NUMBER("1234.9876Ex-7")                ; REAL_ERG == 1234.9876Ex-7
AXIS_ERG=AXNAME("X")                            ; AXIS_ERG == X
```

1.9.3 Concatenation of strings (<<)

Function

The function "concatenation strings" allows a string to be configured from individual components.

The concatenation is realized using the operator "<<". This operator has STRING as the target type for all combinations of basic types CHAR, BOOL, INT, REAL, and STRING. Any conversion that may be required is carried out according to existing rules.

Syntax

```
<any_type> << <any_type>
```

Meaning

`<any_type>`:	Variable, type CHAR, BOOL, INT, REAL or STRING
`<<` :	Operator to chain variables (<any_type>) to configure a character string (type STRING). This operator is also available alone as a so-called "unary" variant. This can be used for explicit type converter to STRING (not for FRAME and AXIS): `<< <any_type>`

For example, such a message or a command can be configured from text lists and parameters can be inserted (for example a block name):
`MSG(STRG_TAB[LOAD_IDX]<<BAUSTEIN_NAME)`

Note

The intermediate results of string concatenation must not exceed the maximum string length.

Note

The FRAME and AXIS types cannot be used together with the operator "<<".

Examples

Example 1: Concatenation of strings

```
Program code                                          Comment
DEF INT IDX=2
DEF REAL VALUE=9.654
DEF STRING[20] STRG="INDEX:2"
IF STRG=="Index:"<<IDX GOTOF NO_MSG
MSG("Index:"<<IDX<<"/value:"<<VALUE)                  ; Display:
                                                      "Index:2/value:9.654"
NO_MSG:
```

Example 2: Explicit type conversion with <<

Program code	Comment
DEF REAL VALUE=3.5	
<<VALUE	; The specified REAL type variable is converted into a STRING type.

1.9.4 Conversion to lower/upper case letters (TOLOWER, TOUPPER)

Function

The "conversion to lower/upper case letters" function allows all of the letters of a string to be converted into a standard representation.

Syntax

```
<STRING_ERG>=TOUPPER("<string>")
<STRING_ERG>=TOLOWER("<string>")
```

Meaning

TOUPPER:	Using the TOUPPER command, all of the letters in a character string are converted into **upper case** letters.
TOLOWER:	Using the TOLOWER command, all of the letters in a character string are converted into **lower case** letters.
<string>:	Character string that is to be converted Type: STRING
<STRING_ERG>:	Variable for the result of the conversion Type: STRING

Example

Because user inputs can be initiated on the operator interface, they can be given standard capitalization (upper or lower case):

```
Program code
DEF STRING [29] STRG
...
IF "LEARN.CNC"==TOUPPER(STRG) GOTOF LOAD_LEARN
```

1.9.5 Determine length of string (STRLEN)

Function

The STRLEN command can be used to determine the length of a character string.

Syntax

```
<INT_ERG>=STRLEN("<STRING>")
```

Meaning

STRLEN:	The STRLEN command determines the length of the specified character string. The number of characters that are not the 0 character, counting from the beginning of the string is returned.
<string>:	Character string whose length is to be determined Type: STRING
<INT_ERG>:	Variable for the result of the determination Type: INT

Example

In conjunction with the single character access, this function allows the end of a character string to be determined:

Program code

```
IF (STRLEN(BAUSTEIN_NAME)>10) GOTOF ERROR
```

1.9.6 Search for character/string in the string (INDEX, RINDEX, MINDEX, MATCH)

Function

This functionality searches for single characters or a string within a string. The function results specify where the character/string is positioned in the string that has been searched.

Syntax

`INT_ERG=INDEX(STRING,CHAR)` ; **Result type: INT**

`INT_ERG=RINDEX(STRING,CHAR)` ; **Result type: INT**

`INT_ERG=MINDEX(STRING,STRING)` ; **Result type: INT**

`INT_ERG=MATCH(STRING,STRING)` ; **Result type: INT**

Semantics

Search functions: It supplies the position in the string (fist parameter) where the search has been successful. If the character/string cannot be found, then the value -1 is returned. The first character has position 0.

Meaning

INDEX:	Searches for the character specified as second parameter (from the beginning) in the first parameter.
RINDEX:	Searches for the character specified as second parameter (from the end) in the first parameter.
MINDEX:	Corresponds to the INDEX function, except for the case that a list of characters is transferred (as string) in which the index of the first found character is returned.
MATCH:	Searches for a string in a string.

This allows strings to be broken up according to certain criteria, for example, at positions with blanks or path separators ("/").

Example

Breaking up an input into path and block names

```
Program code                                                    Comment
DEF INT PFADIDX, PROGIDX
DEF STRING[26] INPUT
DEF INT LISTIDX
INPUT = "/_N_MPF_DIR/_N_EXECUTE_MPF"
LISTIDX = MINDEX (INPUT, "M,N,O,P") + 1                         ; The value returned in LISTIDX is 3;
                                                                  because "N" is the fist character in
                                                                  the parameter INPUT from the
                                                                  selection list starting from the
                                                                  beginning.
PFADIDX = INDEX (INPUT, "/") +1                                 ; Therefore the following applies:
                                                                  PFADIDX = 1
PROGIDX = RINDEX (INPUT, "/") +1                                ; Therefore the following applies:
                                                                  PROGIDX = 12
                                                                  The SUBSTR function introduced in the
                                                                  next section can be used to break-up
                                                                  variable INPUT into the components
                                                                  "path" and "module":
VARIABLE = SUBSTR (INPUT, PFADIDX, PROGIDX-PFADIDX-1)           ; Then returns "_N_MPF_DIR"
VARIABLE = SUBSTR (INPUT, PROGIDX)                              ; Then returns "_N_EXECUTE_MPF"
```

1.9.7 Selection of a substring (SUBSTR)

Function

Arbitrary parts within a string can be read with the SUBSTRING function.

Syntax

```
<STRING_ERG>=SUBSTR(<string>,<index>,<length>)
<STRING_ERG>=SUBSTR(<string>,<index>)
```

Meaning

SUBSTR:	This function returns a substring from <string>, starting with <index> with the specified <length>. If the parameter <length> is not specified, the function returns a substring starting with <index> until the end of the string.
<index>:	Start position of the substring within the string. If the start position is after the end of the string, an empty string (" ") is returned. First character of the string: Index = 0 Range of values: 0 ... (string length - 1)
<length>:	Length of the substring. If too long a length is specified, only the substring up to the end of the string is returned. Range of values: 1 ... (string length - 1)

Example

```
Program code                                          Comment
DEF STRING[29] ERG
; 1
; 0123456789012345678
ERG = SUBSTR("QUITTUNG: 10 to 99", 10, 2)           ; ERG == "10"
ERG = SUBSTR("QUITTUNG: 10 to 99", 10)              ; ERG == "10 to 99"
```

1.9.8 Reading and writing of individual characters

Function

Individual characters can be read and written within a string.

The following supplementary conditions must be observed:

- Only possible with user-defined variables, not with system variables
- Individual characters of a string are only transferred "call by value" for subprogram calls

Syntax

```
<Character>=<string>[<index>]
<Character>=<string_array>[<array_index>,<index>]
<String>[<index>]=<character>
<String_array>[<array_index>,<index>]=<character>
```

Meaning

<string>:	Any string
<character>:	Variable of type CHAR
<index>:	Position of the character within the string. First character of the string: Index = 0 Range of values: 0 ... (string length - 1)

Examples

Example 1: Variable message

```
Program code                                Comment
; 0123456789
DEF STRING [50] MESSAGE = "Axis n has reached position"
MESSAGE [6] = "X"
MSG (MESSAGE)                              ; "Axis X has reached position"
```

Example 2: Evaluating a system variable

```
Program code                                Comment
DEF STRING[50] STRG                        ; Buffer for system variable
...
STRG = $P_MMCA                             ; Load system variable
IF STRG[0] == "E" GOTO ...                 ; Evaluating the system variable
```

Example 3: Parameter transfer "call by value" and "call by reference"

```
Program code                                          Comment
; 0123456
DEF STRING[50] STRG = "Axis X"
DEF CHAR CHR
...
EXTERN UP_VAL(ACHSE)                                ;  Definition of subprogram with
                                                       "call by value" parameters
```

Program code	Comment
EXTERN UP_REF(VAR ACHSE)	; Definition of subprogram with "call by reference" parameters
...	
UP_VAL(STRG[6])	; Parameter transfer "by value"
...	
CHR = STRG[6]	; Buffer
UP_REF(CHR)	; Parameter transfer "by reference"

1.9.9 Formatting a string (SPRINT)

Function

Using the pre-defined SPRINT function, character strings can be formatted and e.g. prepared for output on external devices (also see "Process DataShare - output to an external device/file (EXTOPEN, WRITE, EXTCLOSE) (Page 605)").

Syntax

```
"<Result_string>"=SPRINT("<Format_string>",<value_1>,<value_2>,...,
<value_n>)
```

Meaning

SPRINT:	Identifier for a pre-defined function that supplies a value, type STRING.
"<Format_String>":	Character string that contains fixed and variable elements. The variable elements are defined using the format control character % and a subsequent format description.
< value_1>,< value_2>,…,< value_n>:	Value in the form of a constant or NC variables, which is inserted at the location where the nth format control character % is located, corresponding to the format description in the <format_string>.
"<result_string>":	Formatted character string (maximum 400 bytes)

Format descriptions available

%B:	Conversion into the "TRUE" string, if the value to be converted:
	• Is not equal to 0.
	• Is not an empty string (for string values).
	Conversion into the "FALSE" string, if the value to be converted:
	• Is equal to 0.
	• Is an empty string.
	Example:
	`N10 DEF BOOL BOOL_VAR=1`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF BOOL_VAR:%B", BOOL_VAR)`
	Result: The character string "CONTENT OF BOOL_VAR:TRUE" is written to the RESULT string variable.

%C:	Conversion into an ASCII character.
	Example:
	`N10 DEF CHAR CHAR_VAR="X"`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF CHAR_VAR:%C",CHAR_VAR)`
	Result: The character string "CONTENT OF CHAR_VAR:X is written to the string variable RESULT.

%D:	Conversion into a string with an integer value (INTEGER).
	Example:
	`N10 DEF INT INT_VAR=123`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF INT_VAR:%D",INT_VAR)`
	Result: The character string "CONTENT OF INT_VAR:123" is written to the string variable RESULT.

%<m>D:	Conversion into a string with an integer value (INTEGER). The string has a minimum length of <m> characters. The missing locations are filled with spaces, left-justified.
	Example:
	`N10 DEF INT INT_VAR=-123`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF INT_VAR:%6D",INT_VAR)`
	Result: The character string "CONTENT OF INT_VAR:xx-123" is written to string variable RESULT ("x" in the example represents spaces).

%F:	Conversion into a string with a decimal number with 6 decimal places. Where relevant, the decimal places are rounded-off or filled with 0.
	Example:
	`N10 DEF REAL REAL_VAR=-1.2341234EX+03`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF REAL_VAR:%F",REAL_VAR)`
	Result: The character string "CONTENT OF REAL_VAR:-1234.123400" is written to the string variable RESULT.

%<m>F:	Conversion into a string with a decimal number with 6 decimal places and a total length of at least <m> characters. Where relevant, the decimal places are rounded-off or filled with 0. Missing characters are filled up to the total length <m> using spaces, left-justified. **Example:** N10 DEF REAL REAL_VAR=-1.23412345678EX+03 N20 DEF STRING[80] RESULT N30 RESULT=SPRINT("CONTENT OF REAL_VAR:%15F",REAL_VAR) Result: The character string "CONTENT OF REAL_VAR: xx-1234.123457" is written to the string variable RESULT ("x" in the example represents spaces).
%.<n>F:	Conversion into a string with a decimal number with <n> decimal places. Where relevant, the decimal places are rounded-off or filled with 0. **Example:** N10 DEF REAL REAL_VAR=-1.2345678EX+03 N20 DEF STRING[80] RESULT N30 RESULT=SPRINT("CONTENT OF REAL_VAR:%.3F",REAL_VAR) Result: The character string "CONTENT OF REAL_VAR:-1234.568" is written to the string variable RESULT.
%<m>.<n>F:	Conversion into a string with a decimal number with <n> decimal places and a total length of at least <m> characters. Where relevant, the decimal places are rounded-off or filled with 0. Missing characters are filled up to the total length <m> using spaces, left-justified. **Example:** N10 DEF REAL REAL_VAR=-1.2341234567890EX+03 N20 DEF STRING[80] RESULT N30 RESULT=SPRINT("CONTENT OF REAL_VAR:%10.2F",REAL_VAR) Result: The character string "CONTENT OF REAL_VAR:xx-1234.12" is written to the string variable RESULT ("x" in the example represents spaces).
%E:	Conversion into a string with a decimal number in the exponential representation. The mantissa is saved, normalized with one pre-decimal place and 6 decimal places. Where relevant, the decimal places are rounded-off or filled with 0. The exponent starts with the keyword "EX". It is followed by the sign ("+" or "-") and a two or three-digit number. **Example:** N10 DEF REAL REAL_VAR=-1234.567890 N20 DEF STRING[80] RESULT N30 RESULT=SPRINT("CONTENT OF REAL_VAR:%E",REAL_VAR) Result: The character string "CONTENT OF REAL_VAR:-1.234568EX+03" is written to the string variable RESULT.

%<m>E:	Conversion into a string with a decimal number in the exponential representation and a total length of at least <m> characters. The missing characters are filled with spaces, left-justified. The mantissa is saved, normalized with one pre-decimal place and 6 decimal places. Where relevant, the decimal places are rounded-off or filled with 0. The exponent starts with the keyword "EX". It is followed by the sign ("+" or "-") and a two or three-digit number.
	Example:
	`N10 DEF REAL REAL_VAR=-1234.5`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF REAL_VAR:%20E",REAL_VAR)`
	Result: The character string "CONTENT OF REAL_VAR:xxxxxx-1.234500EX+03" is written to the string variable RESULT ("x" in the example represents spaces).

%.<n>E:	Conversion into a string with a decimal number in the exponential representation. The mantissa is saved, normalized with one pre-decimal place and <n> decimal places. Where relevant, the decimal places are rounded-off or filled with 0. The exponent starts with the keyword "EX". It is followed by the sign ("+" or "-") and a two or three-digit number.
	Example:
	`N10 DEF REAL REAL_VAR=-1234.5678`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF REAL_VAR:%.2E",REAL_VAR)`
	Result: The character string "CONTENT OF REAL_VAR:-1.23EX+03" is written to the string variable RESULT.

%<m>.<n>E:	Conversion into a string with a decimal number in the exponential representation and a total length of at least <m> characters. The missing characters are filled with spaces, left-justified. The mantissa is saved, normalized with one pre-decimal place and <n> decimal places. Where relevant, the decimal places are rounded-off or filled with 0. The exponent starts with the keyword "EX". It is followed by the sign ("+" or "-") and a two or three-digit number.
	Example:
	`N10 DEF REAL REAL_VAR=-1234.5678`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF REAL_VAR:%12.2E", REAL_VAR)`
	Result: The character string "CONTENT OF REAL_VAR:xx-1.23EX+03" is written to the string variable RESULT ("x" in the example represents spaces).

%G:	Conversion into a string with a decimal number – depending on the value range – in a decimal or exponential representation: If the absolute value to be represented is less than 1.0EX-04 or greater than/equal to 1.0EX+06, then the exponential notation is selected, otherwise the decimal notation. A maximum of six significant places are displayed or if required, rounded-off.
	Example with decimal notation:
	`N10 DEF REAL REAL_VAR=1.234567890123456EX-04`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF REAL_VAR:%G",REAL_VAR)`
	Result: The character string "CONTENT OF REAL_VAR:0.000123457" is written to the string variable RESULT.
	Example with exponential notation:
	`N10 DEF REAL REAL_VAR=1.234567890123456EX+06`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF REAL_VAR:%G",REAL_VAR)`
	Result: The character string "CONTENT OF REAL_VAR:1.23457EX+06" is written to the string variable RESULT.

%<m>G:	Conversion into a string with a decimal number – depending on the value range – in a decimal or exponential notation (like %G). The string has a total length of at least <m> characters. The missing characters are filled with spaces, left-justified.
	Example with decimal notation:
	`N10 DEF REAL REAL_VAR=1.234567890123456EX-04`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF REAL_VAR:%15G",REAL_VAR)`
	Result: The character string "CONTENT OF REAL_VAR:xxxx0.000123457" is written to the string variable RESULT ("x" in the example represents spaces).
	Example with exponential notation:
	`N10 DEF REAL REAL_VAR=1.234567890123456EX+06`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF REAL_VAR:%15G",REAL_VAR)`
	Result: The character string "CONTENT OF REAL_VAR:xxx1.23457EX+06" is written to the string variable RESULT ("x" in the example represents spaces).

%.<n>G:	Conversion into a string with a decimal number – depending on the value range – in a decimal or exponential representation. A maximum of <n> significant places are displayed or if required, rounded-off. If the absolute value to be represented is less than 1.0EX-04 or greater than/equal to 1.0EX(+<n>), then the exponential notation is selected, otherwise the decimal notation.
	Example with decimal notation:
	`N10 DEF REAL REAL_VAR=1.234567890123456EX-04`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF REAL_VAR:%.3G",REAL_VAR)`
	Result: The character string "CONTENT OF REAL_VAR:0.000123" is written to the string variable RESULT.
	Example with exponential notation:
	`N10 DEF REAL REAL_VAR=1.234567890123456EX+03`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT = SPRINT("CONTENT OF REAL_VAR:%.3G",REAL_VAR)`
	Result: The character string "CONTENT OF REAL_VAR:1.23EX+03" is written to the string variable RESULT.

%<m>.<n>G:	Conversion into a string with a decimal number – depending on the value range – in a decimal or exponential notation (like %.<n>G). The string has a total length of at least <m> characters. The missing characters are filled with spaces, left-justified.
	Example with decimal notation:
	`N10 DEF REAL REAL_VAR=1.234567890123456EX-04`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF REAL_VAR:%12.4G",REAL_VAR)`
	Result: The character string "CONTENT OF REAL_VAR:xxx0.0001235" is written to the string variable RESULT ("x" in the example represents spaces).
	Example with exponential notation:
	`N10 DEF REAL REAL_VAR=1.234567890123456EX+04`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF REAL_VAR:%12.4G",REAL_VAR)`
	Result: The character string "CONTENT OF REAL_VAR:xx1.235EX+06" is written to the string variable RESULT ("x" in the example represents spaces).

%.<n>P:	Converting a REAL value into an INTEGER value taking into account <n> decimal places. The INTEGER value is output as a 32-bit binary number. If the value to be converted cannot be represented with 32 bits, then processing is interrupted with an alarm.
	As a byte sequence generated using the format instruction %.<n>P can also contain binary zeroes, then the total string that is generated in this way no longer corresponds to the conventions of the NC data type STRING. As a consequence, it can neither be saved in a variable, type STRING, nor be further processed using the string commands of the NC language. The only possible use is to transfer the parameter to the WRITE command with output at an appropriate external device (see the following example).
	As soon as the <Format_String> contains a format description, type %P then the complete string, with the exception of the binary number generated with %.<n>P, is output corresponding to the MD10750 $MN_SPRINT_FORMAT_P_CODE in the ASCII character code, ISO (DIN6024) or EIA (RS244). If a character that cannot be converted is programmed, then processing is interrupted with an alarm.
	Example:
	`N10 DEF REAL REAL_VAR=123.45`
	`N20 DEF INT ERROR`
	`N30 DEF STRING[20] EXT_DEVICE="/ext/dev/1"`
	`...`
	`N100 EXTOPEN(ERROR,EXT_DEVICE)`
	`N110 IF ERROR <> 0`
	`... ; error handling`
	`N200 WRITE(ERROR,EXT_DEVICE,SPRINT("INTEGER BINARY CODED:%.3P",REAL_VAR)`
	`N210 IF ERROR <> 0`
	`… ; error handling`
	Result: The string "INTEGER BINARY CODED: 'H0001E23A'" is transferred to the output device /ext/dev/1. The hexadecimal value 0x0001E23A corresponds to the decimal value 123450.

%<m>.<n>P:	Conversion of a REAL value corresponding to the setting in machine data MD10751 $MN_SPRINT_FORMAT_P_DECIMAL into a string with:
	• An integer of <m> + <n> places **or**
	• A decimal number with a maximum of <m> pre-decimal places and precisely <n> decimal places.
	Just the same as for the format description %.<n>P, the complete string is saved in the character code defined by MD10750 $MN_SPRINT_FORMAT_P_CODE.
	Conversion for MD10751 = 0:
	The REAL value is converted into a string with an integer number of <m> + <n> places. If required, decimal places are rounded-off to <n> places or filled with 0. The missing pre-decimal places are filled with spaces. The minus sign is attached, left-justified; a space is entered instead of the plus sign.
	Example:
	`N10 DEF REAL REAL_VAR=-123.45`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("PUNCHED TAPE FORMAT:%5.3P",REAL_VAR)`
	Result: The character string "PUNCHED TAPE FORMAT:-xx123450" is written to the string variable RESULT ("x" in the example represents spaces).
	Conversion for MD10751 = 1:
	The REAL value is converted into a string with a decimal number with a maximum of <m> pre-decimal places and precisely <n> decimal places. Where necessary, the pre-decimal places are cut-off and the decimal places are rounded-off or filled with 0. If <n> is equal to 0, then the decimal point is also omitted.
	Example:
	`N10 DEF REAL REAL_VAR1=-123.45`
	`N20 DEF REAL REAL_VAR2=123.45`
	`N30 DEF STRING[80] RESULT`
	`N40 RESULT=SPRINT("PUNCHED TAPE FORMAT:%5.3P VAR2:%2.0P", REAL_VAR1,REAL_VAR2)`
	Result: The character string "PUNCHED TAPE FORMAT:-123.450 VAR2:23" is written to the string variable RESULT.

%S:	Inserting a string.
	Example:
	`N10 DEF STRING[16] STRING_VAR="ABCDEFG"`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF STRING_VAR:%S",STRING_VAR)`
	Result: The character string "CONTENT OF STRING_VAR:ABCDEFG" is written to the string variable RESULT.

%<m>S:	Inserting a string with a minimum of <m> characters. The missing places are filled with spaces.
	Example:
	`N10 DEF STRING[16] STRING_VAR="ABCDEFG"`
	`N20 DEF STRING[80] RESULT`
	`N30 RESULT=SPRINT("CONTENT OF STRING_VAR:%10S",STRING_VAR)`
	Result: The character string "CONTENT OF STRING_VAR:xxxABCDEFG" is written to the string variable RESULT ("x" in the example represents spaces).

%.<n>S:	Inserting <n> characters of a string (starting with the first character). **Example:** N10 DEF STRING[16] STRING_VAR="ABCDEFG" N20 DEF STRING[80] RESULT N30 RESULT=SPRINT("CONTENT OF STRING_VAR:%.3S",STRING_VAR) Result: The character string "CONTENT OF STRING_VAR:ABC" is written to the string variable RESULT.
%<m>.<n>S:	Inserting <n> characters of a string (starting with the first character). The total length of the generated string has at least <m> characters. The missing places are filled with spaces. **Example:** N10 DEF STRING[16] STRING_VAR="ABCDEFG" N20 DEF STRING[80] RESULT N30 RESULT=SPRINT("CONTENT OF STRING_VAR:%10.5S", STRING_VAR) Result: The character string "CONTENT OF STRING_VAR:xxxxxABCDE" is written to the string variable RESULT ("x" in the example represents spaces).
%X:	Converting an INTEGER value into a string with the hexadecimal notation. **Example:** N10 DEF INT INT_VAR='HA5B8' N20 DEF STRING[80] RESULT N30 RESULT=SPRINT("INTEGER HEXADECIMAL:%X",INT_VAR) Result: The character string "INTEGER HEXADECIMAL:A5B8" is written to the string variable RESULT.

Note

A property of the NC language, where a distinction is not made between upper case and lower case letters for identifiers and keywords, also applies to the format descriptions. As a consequence, you can program using either lower case or upper case letters without any functional difference.

Combination options

The following table provides information as to which NC data types can be combined with which format description. The rules regarding implicit data type conversion apply (see "Data types (Page 52)").

	NC data types						
	BOOL	CHAR	INT	REAL	STRING	AXIS	FRAME
%B	+	+	+	+	+	-	-
%C	-	+	-	-	+	-	-
%D	+	+	+	+	-	-	-
%F	-	-	+	+	-	-	-

	NC data types						
%E	-	-	+	+	-	-	-
%G	-	-	+	+	-	-	-
%S	-	+	-	-	+	-	-
%X	+	+	+	-	-	-	-
%P	-	-	+	+	-	-	-

Note

The table indicates that the NC data types AXIS and FRAME cannot be directly used in the SPRINT function. However it is possible:

- To convert the AXIS data type into a string using the AXSTRING function – which can then be processed with SPRINT.
- To read the individual values of the FRAME data type per frame component access. As a consequence, a REAL data type is obtained, which can be processed with SPRINT.

1.10 Program jumps and branches

1.10.1 Return jump to the start of the program (GOTOS)

Function

The `GOTOS` command can be used to jump back to the beginning of a main or sub program in order to repeat the program.

Machine data can be used to set that for every return jump to the beginning of the program:

- The program runtime is set to "0".
- Workpiece counting is incremented by the value "1".

Syntax

```
GOTOS
```

Meaning

GOTOS: Jump instruction where the destination is the beginning of the program.
The execution is controlled via the NC/PLC interface signal:
DB21, to DBX384.0 (control program branching)

Value:	Meaning:
0	No return jump to the beginning of the program. Program execution is resumed with the next part program block after GOTOS.
1	Return jump to the beginning of the program. The part program is repeated.

Supplementary conditions

- GOTOS internally initiates a STOPRE (pre-processing stop).
- For a subprogram with data definitions (LUD variables) with the GOTOS a jump is made to the first program block after the definition section, i.e. data definitions are not executed again. This is the reason that the defined variables retain the value reached in the GOTOS block and are not reset to the standard values programmed in the definition section.
- The GOTOS command is not available in synchronized actions and technology cycles.

Example

```
Program code              Comment
N10 ...                   ; Beginning of the program
...
N90 GOTOS                 ; Jump to beginning of the program
...
```

1.10.2 Program jumps to jump markers (GOTOB, GOTOF, GOTO, GOTOC)

Function

Jump markers (labels) can be set in a program, that can be jumped to from another location within the same program using the commands GOTOF, GOTOB, GOTO or GOTOC. Program execution is resumed with the instruction that immediately follows the destination marker. This means that branches can be realized within the program.

In addition to jump markers, main and sub-block numbers are possible as jump designation.

If a jump condition (IF ...) is formulated before the jump instruction, the program jump is only executed if the jump condition is fulfilled.

Syntax

```
GOTOB <jump destination>
IF <jump condition> = TRUE GOTOB <jump destination>
GOTOF <jump destination>
IF <jump condition> = TRUE GOTOF <jump destination>
GOTO <jump destination>
IF <jump condition> = TRUE GOTO <jump destination>
GOTOC <jump destination>
IF <jump condition> = TRUE GOTOC <jump destination>
```

Meaning

`GOTOB`: Jump instruction with jump destination towards the beginning of the program.

`GOTOF`: Jump instruction with jump destination towards the end of the program.

`GOTO`: Jump instruction with jump destination search. The search is first made in the direction of the end of the program, then in the direction of the beginning of the program.

`GOTOC`: Same effect as for GOTO with the difference that Alarm 14080 "Jump designation not found" is suppressed.

This means that program execution is not interrupted in the case that the jump destination search is unsuccessful – but is continued with the program line following the GOTOC command.

`<jump destination>`: Jump destination parameter

Possible data include:

- <jump marker>: Jump destination is the jump marker (label) set in the program with a user-defined name: `<jump marker>:`
- <block number>: Jump destination is main block or sub-block number (e.g.: `200`, `N300`)
- STRING type variable: Variable jump destination. The variable stands for a jump marker or a block number.

`IF`: Keyword to formulate the jump condition.

The jump condition permits all comparison and logical operations (result: TRUE or FALSE). The program jump is executed if the result of this operation is TRUE.

Note

Jump markers (labels)

Jump markers are always located at the beginning of a block. If a program number exists, the jump marker is located immediately after the block number.

The following rules apply when naming jump markers:

- Number of characters:
  - Minimum 2
  - Maximum 32
- Permissible characters are:
  - Letters
  - Numbers
  - Underscores
- The first two characters must be letters or underscores.
- The name of the jump marker is followed by a colon (":").

Supplementary conditions

- The jump destination can only be a block with jump marker or block number, that is located **within** the program.
- A jump instruction without jump condition must be programmed in a separate block. This restriction does not apply to jump instructions with jump conditions. In this case, several jump instructions can be formulated in a block.
- For programs with jump instructions without jump conditions, the end of the program `M2`/`M30` doesn't necessarily have to be be at the end of the program.

Examples

Example 1: Jumps to jump markers

```
Program code                    Comment
N10 …
N20 GOTOF Label_1               ; Jump towards the end of the program to the jump
                                  marker "Label_1".
N30 …
N40 Label_0: R1=R2+R3           ; Jump marker "Label_0" set.
N50 …
N60 Label_1:                    ; Jump marker "Label_1" set.
N70 …
N80 GOTOB Label_0               ; Jump in the direction of the beginning of the
                                  program to the jump marker "Label_0".
N90 …
```

Example 2: Indirect jump to the block number

```
Program code                    Comment
N5 R10=100
N10 GOTOF "N"<<R10              ; Jump to the block whose block number is located
                                  in R10.
...
N90 ...
N100 ...                        ; Jump destination
N110 ...
...
```

Example 3: Jump to variable jump destination

```
Program code                    Comment
DEF STRING[20] DESTINATION
DESTINATION = "Marker2"
GOTOF DESTINATION               ; Jump in the direction of the end of the program
                                  to the variable jump destination DESTINATION.
Marker 1: T="Drill1"
...
Marker 2: T="Drill2"            ; Jump destination
...
```

Example 4: Jump with jump condition

```
Program code                                    Comment
N40 R1=30 R2=60 R3=10 R4=11 R5=50 R6=20         ; Assignment of the initial values.
N41 LA1: G0 X=R2*COS(R1)+R5 Y=R2*SIN(R1)+R6     ; Jump marker LA1 set.
N42 R1=R1+R3 R4=R4-1
N43 IF R4>0 GOTOB LA1                           ; If the jump condition is
                                                  fulfilled, then a jump in the
                                                  direction of the beginning of the
                                                  program to jump marker LA1.
N44 M30                                         ; End of program
```

1.10.3 Program branch (CASE ... OF ... DEFAULT ...)

Function

The CASE function provides the possibility of checking the actual value (type: INT) of a variable or an arithmetic function and, depending on the result, to jump to different positions in the program.

Syntax

```
CASE(<expression>) OF <constant_1> GOTOF <jump destination_1>
<constant_2> GOTOF <jump destination_2> ... DEFAULT GOTOF <jump
destination_n>
```

Meaning

CASE:	Jump statement
<expression>:	Variable or arithmetic function
OF:	Keyword to formulate conditional program branches.
<constant_1>:	First specify constant value for the variable or arithmetic function Type: INT
<constant_2>:	Second specified constant value for the variable or arithmetic function Type: INT
DEFAULT:	For the cases where the variable or arithmetic function does not assume any of the specified constant values, the DEFAULT instruction can be used to determine the branch destination. **Note:** If the DEFAULT instruction is not programmed, then in these cases, the block following the CASE instruction is the jump destination.
GOTOF:	Jump instruction with jump destination towards the end of the program. Instead of GOTOF all other GOTO commands can be programmed (refer to the subject "Program jumps to jump markers").
<jump destination_1>:	A branch is made to this jump destination if the value of the variable or arithmetic function corresponds to the first specific constant. The jump destination can be specified as follows: <jump marker>: Jump destination is the jump marker (label) set in the program with a user-defined name: <jump marker>: <block number>: Jump destination is main block or sub-block number (e.g.: 200, N300) STRING type variable: Variable jump destination. The variable stands for a jump marker or a block number.
<jump destination_2>:	A branch is made to this jump destination if the value of the variable or arithmetic function corresponds to the second specified constant.
<jump destination_n>:	A branch is made to this jump destination if the value of the variable does not assume the specified constant value.

Example

Program code

```
...
N20 DEF INT VAR1 VAR2 VAR3
N30 CASE(VAR1+VAR2-VAR3) OF 7 GOTOF Label_1 9 GOTOF Label_2 DEFAULT GOTOF Label_3
N40 Label_1: G0 X1 Y1
N50 Label_2: G0 X2 Y2
N60 Label_3: G0 X3 Y3
...
```

The CASE instruction from N30 defines the following program branch possibilities:

1. If the value of the arithmetic function VAR1+VAR2-VAR3 = 7, then jump to the block with the jump marker definition "Label_1" (→ N40).
2. If the value of the arithmetic function VAR1+VAR2-VAR3 = 9, then jump to the block with the jump marker definition "Label_2" (→ N50).
3. If the value of the arithmetic function VAR1+VAR2-VAR3 is neither 7 nor 9, then jump to the block with the jump marker definition "Label_3" (→ N60).

1.11 Repeat program section (REPEAT, REPEATB, ENDLABEL, P)

Function

Program section repetition allows you to repeat existing program sections within a program in any order.

The program lines or program sections to be repeated are identified by jump markers (labels).

Note

Jump markers (labels)

Jump markers are always located at the beginning of a block. If a program number exists, the jump marker is located immediately after the block number.

The following rules apply when naming jump markers:

- Number of characters:
  - Minimum 2
  - Maximum 32
- Permissible characters are:
  - Letters
  - Numbers
  - Underscores
- The first two characters must be letters or underscores.
- The name of the jump marker is followed by a colon (":").

Syntax

1. Repeat individual program line:

```
<jump marker>: ...
...
REPEATB <jump marker> P=<n>
...
```

2. Repeat program section between jump marker and REPEAT statement:

```
<jump marker>: ...
...
REPEAT <jump marker> P=<n>
...
```

3. Repeat section between two jump markers:

```
<start jump marker>: ...
...
<end jump marker>: ...
...
REPEAT <start jump marker> <end jump marker> P=<n>
...
```

Note

It is not possible to nest the `REPEAT` statement with the two jump markers in parentheses. If the `<start jump marker>` appears before the `REPEAT` statement and the `<end jump marker>` is not reached before the `REPEAT` statement, the section between the `<start jump marker>` and the `REPEAT` statement will be repeated.

4. Repeat section between jump marker and ENDLABEL:

```
<jump marker>: ...
...
ENDLABEL: ...
...
REPEAT <jump marker> P=<n>
...
```

Note

It is not possible to nest the `REPEAT` statement with the `<jump marker>` and the `ENDLABEL` in parentheses. If the `<jump marker>` appears before the `REPEAT` statement and the `ENDLABEL` is not reached before the `REPEAT` statement, the section between the `<jump marker>` and the `REPEAT` statement will be repeated.

Meaning

REPEATB:	Command for repeating a program line
REPEAT:	Command for repeating a program section
<jump marker>:	The <jump marker> identifies: • The program line to be repeated (in the case of REPEATB) or • The start of the program section to be repeated (in the case of REPEAT) The program line identified by the <jump marker> can appear before or after the REPEAT/REPEATB statement. The search initially commences toward the start of the program. If the jump marker is not found in this direction, the search continues working toward the end of the program. **Exception:** If the program section between the jump marker and the REPEAT statement needs to be repeated (see 2. under Syntax), the program line identified by the <jump marker> has to appear **before** the REPEAT statement, since in this case the search runs **only** toward the beginning of the program. If the line with the <jump marker> contains further operations, these are executed again on each repetition.
ENDLABEL:	Keyword marking the end of a program section to be repeated. If the line with the ENDLABEL contains further operations, these are executed again on each repetition. ENDLABEL can be used more than once in the program.
P:	Address for specifying the number of repetitions
<n>:	Number of program section repetitions Type: INT The program section to be repeated is repeated <n> times. After the last repetition, the program is resumed at the line following the REPEAT/REPEATB line. **Note:** In the absence of a number being specified for P=<n>, the program section is repeated just once.

Examples

Example 1: Repeat individual program line

```
Program code                              Comment
N10 POSITION1: X10 Y20
N20 POSITION2: CYCLE(0,,9,8)              ; Position cycle
N30 ...
N40 REPEATB POSITION1 P=5                 ; Execute BLOCK N10 five times.
N50 REPEATB POSITION2                     ; Execute block N20 once.
N60 ...
N70 M30
```

Example 2: Repeat program section between jump marker and REPEAT statement

```
Program code                    Comment
N5 R10=15
N10 Begin: R10=R10+1            ; Width
N20 Z=10-R10
N30 G1 X=R10 F200
N40 Y=R10
N50 X=-R10
N60 Y=-R10
N70 Z=10+R10
N80 REPEAT BEGIN P=4            ; Execute section from N10 to N70 four times.
N90 Z10
N100 M30
```

Example 3: Repeat section between two jump markers

```
Program code                      Comment
N5 R10=15
N10 Begin: R10=R10+1              ; Width
N20 Z=10-R10
N30 G1 X=R10 F200
N40 Y=R10
N50 X=-R10
N60 Y=-R10
N70 END: Z=10
N80 Z10
N90 CYCLE(10,20,30)
N100 REPEAT BEGIN END P=3         ; Execute section from N10 to N70 three times.
N110 Z10
N120 M30
```

Example 4: Repeat section between jump marker and ENDLABEL

```
Program code                Comment
N10 G1 F300 Z-10
N20 BEGIN1:
N30 X10
N40 Y10
N50 BEGIN2:
N60 X20
N70 Y30
N80 ENDLABEL: Z10
N90 X0 Y0 Z0
N100 Z-10
N110 BEGIN3: X20
N120 Y30
N130 REPEAT BEGIN3 P=3      ; Execute section from N110 to N120 three times.
N140 REPEAT BEGIN2 P=2      ; Execute section from N50 to N80 twice.
N150 M100
N160 REPEAT BEGIN1 P=2      ; Execute section from N20 to N80 twice.
N170 Z10
N180 X0 Y0
N190 M30
```

Example 5: Milling, machine drill position with different technologies

```
Program code                Comment
N10 CENTER DRILL()          ; Load centering drill.
N20 POS_1:                  ; Drilling positions 1
N30 X1 Y1
N40 X2
N50 Y2
N60 X3 Y3
N70 ENDLABEL:
N80 POS_2:                  ; Drilling positions 2
N90 X10 Y5
N100 X9 Y-5
N110 X3 Y3
N120 ENDLABEL:
N130 DRILL()                ; Change drill and drilling cycle.
N140 THREAD(6)              ; Load tap M6 and threading cycle.
N150 REPEAT POS_1           ; Repeat program section once from POS_1 up to ENDLABEL.
N160 DRILL()                ; Change drill and drilling cycle.
N170 THREAD(8)              ; Load tap M8 and threading cycle.
N180 REPEAT POS_2           ; Repeat program section once from POS_2 up to ENDLABEL.
N190 M30
```

Further information

- Program section repetitions can be nested. Each call uses a subprogram level.
- If M17 or RET is programmed during processing of a program section repetition, the repetition is canceled. The program is resumed at the block following the REPEAT line.
- In the actual program display, the program section repetition is displayed as a separate subprogram level.
- If the level is canceled during the program section repetition, the program resumes at the point after the program section repetition call.

  Example:

```
Program code                        Comments
N5 R10=15
N10 BEGIN: R10=R10+1                ; Width
N20 Z=10-R10
N30 G1 X=R10 F200
N40 Y=R10                           ; Interrupt level
N50 X=-R10
N60 Y=-R10
N70 END: Z10
N80 Z10
N90 CYCLE(10,20,30)
N100 REPEAT BEGIN END P=3
N120 Z10                            ; Resume program execution.
N130 M30
```

- Check structures and program section repetitions can be used in combination. There should be no overlap between the two, however. A program section repetition should appear within a check structure branch or a check structure should appear within a program section repetition.
- If jumps and program section repetitions are mixed, the blocks are executed purely sequentially. For example, if a jump is performed from a program section repetition, processing continues until the programmed end of the program section is found.

Example:

```
Program code
N10 G1 F300 Z-10
N20 BEGIN1:
N30 X=10
N40 Y=10
N50 GOTOF BEGIN2
N60 ENDLABEL:
N70 BEGIN2:
N80 X20
N90 Y30
N100 ENDLABEL: Z10
N110 X0 Y0 Z0
N120 Z-10
N130 REPEAT BEGIN1 P=2
N140 Z10
N150 X0 Y0
N160 M30
```

Note

The `REPEAT` statement should appear after the traversing block.

1.12 Check structures

Function

The control processes the NC blocks as standard in the programmed sequence.

This sequence can be variable by programming alternative program blocks and program loops. These check structures are programmed using the key words `IF`, `ELSE`, `ENDIF`, `LOOP`, `FOR`, `WHILE` and `REPEAT`.

NOTICE

Programming error

Check structures may only be inserted in the statement section of a program. Definitions in the program header may not be executed conditionally or repeatedly.

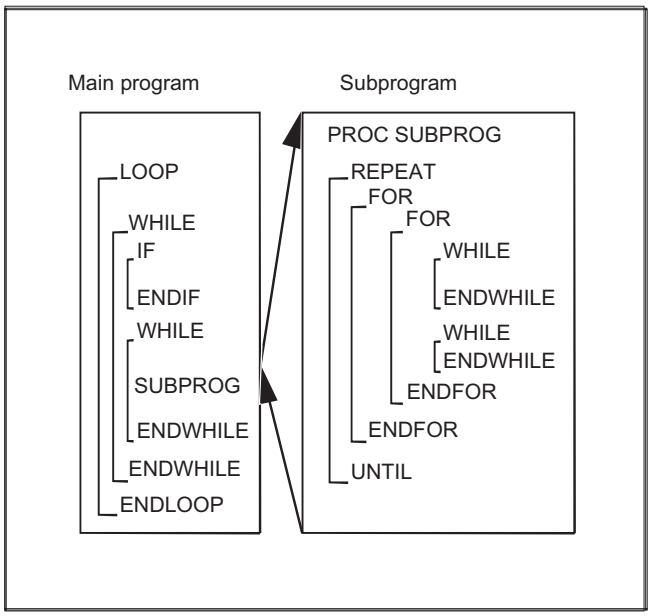
It is not permissible to superimpose macros on keywords for check structures or on branch destinations. No such check is made when the macro is defined.

Effectiveness

The check structure cannot be used program-wide.

Nesting depth

A nesting depth of up to 16 check structures can be set up on each subprogram level.



Runtime response

In interpreter mode (active as standard), it is possible to shorten program processing times more effectively by using program branches than can be obtained with check structures.

There is no difference between program branches and check structures in precompiled cycles.

Current block display for program loops

If only selected blocks are executed within a program loop, the last main run block **before** the program loop is shown in the current block display.

So that the processed selected blocks are also visible in the current block display, e.g. for diagnostic purposes, the decoding single block SBL2 must be activated.

References

Function Manual, Basic Functions, Section: Mode group, channel, program operation, reset response (K1) > Single block > Decoding single block SBL2 with implicit preprocessing stop

Supplementary conditions

- Blocks with check structure elements cannot be suppressed.
- Jumper markers (labels) are not permitted in blocks with check structure elements.
- Check structures are processed interpretively. When a loop end is detected, a search is made for the loop beginning, allowing for the check structures found in the process. For this reason, the block structure of a program is not checked completely in interpreter mode.
- It is not generally advisable to use a mixture of check structures and program branches.
- A check can be made to ensure that check structures are nested correctly when cycles are preprocessed.

1.12.1 Conditional statement and branch (IF, ELSE, ENDIF)

Function

Conditional statement: IF - program block - ENDIF

With a conditional statement, the program block between `IF` and `ENDIF` is only executed when the condition is satisfied.

Branch: IF - program block_1 - ELSE - program block_2 - ENDIF

With a branch, one of two program blocks is always executed.

If the condition is satisfied, program block_1 between `IF` and `ELSE` is executed.

If the condition is **not** satisfied, program block_2 between `ELSE` and `ENDIF` is executed.

Syntax

Conditional statement

```
IF <condition>
Program block                          ; Execution when: <condition> == TRUE
ENDIF
```

Branch

```
IF <condition>
   Program block_1                     ; Execution when: <condition> == TRUE
ELSE
   Program block_2                     ; Execution when: <condition> == FALSE
ENDIF
```

Meaning

IF:	Introduces the conditional statement or branch.
ELSE:	Introduces the alternative program block.
ENDIF:	Marks the end of the conditional statement or branch.
<condition>:	Logical expression that is evaluated as TRUE or FALSE.

Example: Tool change subprogram

```
Program code                                    Comment
PROC L6                                         Tool change routine
N500 DEF INT TNR_AKTUELL                        Variable for active T number
N510 DEF INT TNR_VORWAHL                        Variable for preselected T
                                                number
                                                Determine current tool
N520 STOPRE
N530 IF $P_ISTEST                               In the program test mode ...
N540    TNR_AKTUELL = $P_TOOLNO                 ... The "current" tool is read
                                                from the program context.
N550 ELSE                                       Otherwise ...
N560    TNR_AKTUELL = $TC_MPP6[9998,1]          ... The tool of the spindle is
                                                read-out.
N570 ENDIF
N580 GETSELT(TNR_VORWAHL)                       Read the T number of the pre-
                                                selected tool in the spindle.
N590 IF TNR_AKTUELL <> TNR_VORWAHL              If the pre-selected tool is
                                                still not the current tool, then
                                                ...
N600    G0 G40 G60 G90 SUPA X450 Y300 Z300 D0   ... Approach tool change
                                                position ...
N610 M206                                       ... and execute a tool change.
N620 ENDIF
N630 M17
```

1.12.2 Continuous program loop (LOOP, ENDLOOP)

Function

Endless loops are used in endless programs. At the end of the loop, there is always a branch back to the beginning.

Syntax

```
LOOP
...
ENDLOOP
```

Meaning

LOOP:	Initiates the endless loop.
ENDLOOP:	Marks the end of the loop and results in a return jump to the beginning of the loop.

Example

Program code

```
...
LOOP
MSG ("no tool cutting edge active")
M0
STOPRE
ENDLOOP
...
```

1.12.3 Count loop (FOR ... TO ..., ENDFOR)

Function

The count loop is used if an operation must be repeated with a fixed number of runs.

Syntax

```
FOR <variable> = <initial value> TO <end value>
...
ENDFOR
```

Meaning

FOR:	Initiates the count loop.
ENDFOR:	Marks the end of the loop and results in a return jump to the beginning of the loop, as long as the end value of the count has still not been reached.
<variable>:	Count variable, which is incremented from the initial to the end value and is increased by the value "1" at each run. Type INT or REAL **Note:** The REAL type is used if R parameters are programmed for a count loop, for example. If the count variable is of the REAL type, its value is rounded to an integer.
<initial value>:	Initial value of the count Condition: The start value must be lower than the end value.
<full-scale value>:	End value of the count

Examples

Example 1: INTEGER variable or R parameter as count variable

INTEGER variable as count variable:

```
Program code                          Comment
DEF INT iVARIABLE1
R10=R12-R20*R1 R11=6
FOR iVARIABLE1 = R10 TO R11           ; Count variable = INTEGER variable
 R20=R21*R22+R33
ENDFOR
M30
```

R parameter as count variable:

```
Program code                          Comment
R11=6
FOR R10=R12-R20*R1 TO R11             ; Count variable = R parameter (real variable)
 R20=R21*R22+R33
ENDFOR
M30
```

Example 2: Production of a fixed quantity of parts

```
Program code                          Comment
DEF INT WKPCCOUNT                     ; Defines type INT variable with the name
                                        "WKPCCOUNT".
FOR WKPCCOUNT = 0 TO 100              ; Initiates the count loop. The "WKPCCOUNT"
                                        variable increments from the initial value "0"
                                        to the end value "100".
G01 …
ENDFOR                                ; End of count loop
M30
```

1.12.4 Program loop with condition at start of loop (WHILE, ENDWHILE)

Function

For a WHILE loop, the condition is at the beginning of the loop. The WHILE loop is executed as long as the condition is fulfilled.

Syntax

```
WHILE <condition>
...
ENDWHILE
```

Meaning

WHILE:	Initiates the program loop.
ENDWHILE:	Marks the end of the loop and results in a return jump to the beginning of the loop.
<condition>:	The condition must be fulfilled so that the WHILE loop is executed.

Example

```
Program code                                Comment
...
WHILE $AA_IW[DRILL_AXIS] > -10              ; Call the WHILE loop under the following
                                              condition: The actual WCS setpoint for the
                                              drilling axis must be greater than -10.
G1 G91 F250 AX[DRILL_AXIS] = -1
ENDWHILE
...
```

1.12.5 Program loop with condition at the end of the loop (REPEAT, UNTIL)

Function

For a REPEAT loop, the condition is at the end of the loop. The REPEAT loop is executed once and repeated continuously until the condition is fulfilled.

Syntax

```
REPEAT
...
UNTIL <significance>
```

Meaning

`REPEAT`:	Initiates the program loop.
`UNTIL`:	Marks the end of the loop and results in a return jump to the beginning of the loop.
`<condition>`:	The condition that must be fulfilled so that the REPEAT loop is no longer executed.

Example

```
Program code                    Comment
...
REPEAT                          ; Call the REPEAT loop.
...
UNTIL ...                       ; Check whether the condition is fulfilled.
...
```

1.12.6 Program example with nested check structures

```
Program code                                Comment
LOOP
IF NOT $P_SEARCH                            ; IF no block search
      G1 G90 X0 Z10 F1000
      WHILE $AA_IM[X] <= 100                ; WHILE (setpoint X axis <= 100)
         G1 G91 X10 F500                    ; Drilling pattern
         Z-5 F100
         Z5
```

```
Program code                                    Comment
      ENDWHILE
   ELSE                                         ; ELSE block search
      MSG("No drilling during block
search")
   ENDIF                                        ; ENDIF
   $A_OUT[1] = 1                                ; Next drilling plate
   G4 F2
ENDLOOP
M30
```

1.13 Program coordination (INIT, START, WAITM, WAITMC, WAITE, SETM, CLEARM)

Function

A channel can process its own program independently of other channels. It can control the axes and spindles temporarily assigned to it via the program.

If several channels are involved in the machining of a workpiece it may be necessary to synchronize the programs. There are special statements (commands) for this program coordination.

Note

Program coordination is also possible in its own channels.

Requirement

The relevant channels must be belong to the **same mode group**.

Syntax

```
INIT(<channel no. >,<path specification>,<acknowledgement mode>)
START(<channel no.>,<channel no.>, ... )
WAITM(<marker no.>,<channel no.>,<channel no.>, ...)
WAITMC(<marker no.>,<channel no.>,<channel no.>, ...)
WAITE(<channel no.>,<channel no.>,...)
SETM(<marker no.>,<marker no.>,...)
CLEARM(<marker no.>,<marker no.>,...)
```

Note

The program coordination statements must be programmed in separate blocks.

Meaning

`INIT`: Predefined procedure for selecting the NC program that is to be processed in the specified channel

`<channel no.>`: Number of channel

Type: INT

`<path specification>`: An absolute or relative path to the NC program

Type: STRING

Absolute path specification:

An absolute path must be formed along the following pattern:

Current directory/_N_<name>_MPF

- "Current directory" stands for the selected workpiece directory or the standard directory /_N_MPF_DIR.
- The complete program name must be specified.

Relative path specification:

The same rules apply to relative path specification as for program calls.

`<acknowledgement mode>`: Parameters of the type CHAR

Values: "N" Without acknowledgement

Program execution is continued when the command has been transmitted. The sender is not informed if the command cannot be executed successfully.

"S" Synchronous acknowledgement

The program execution is paused until the receiving component acknowledges the command. If the acknowledgement is positive, the next command is executed. If the acknowledgement is negative, an error message is output.

Note:
If the acknowledgement mode is not specified, synchronous acknowledgement is the default response.

`START`: Predefined procedure to start the selected programs in the other channels

`<channel no.>,...`: Enumeration of the channel numbers

Type: INT

`WAITM`: Predefined procedure to wait for a marker to be reached in the specified channels

The specified marker is set by `WAITM` in the same channel. The previous block is terminated with exact stop. The marker is deleted after synchronization.

10 markers can be set per channel simultaneously.

`<marker no.>`: Number of the marker
Type: INT

`<channel no.>,...`: Enumeration of the channel numbers (same channel does not have to be specified)
Type: INT

`WAITE`: Predefined procedure to wait for the end of program in one or more other channels

`<channel no.>,...`: Enumeration of the channel numbers
Type: INT

`WAITMC`: Predefined procedure to wait for a marker to be reached in the specified channels

In contrast to `WAITM`, exact stop is only initiated if the other channels have not yet reached the marker.

Parameters as for `WAITM`.

`SETM`: Predefined procedure to set one or more markers for the channel coordination

Processing in the same channel is not effected by this.
`SETM` remains valid after reset and NC start.

`<marker no.>,...`: List of the marker numbers

`CLEARM`: Predefined procedure to delete one or more markers for the channel coordination

The processing in own channel is not affected by this
All markers in the channel can be deleted with `CLEARM()`.
`CLEARM(0)` deletes the marker "0".
`CLEARM` remains valid after reset and NC start.

`<marker no.>,...`: List of the marker numbers

Note

Channel number

Channel names must be converted to numbers by means of variables.

⚠ CAUTION

Channel number

Protect the number assignments so that they are not changed unintentionally.

Note

Channel name

Instead of channel numbers, the channel names (identifiers or keywords) defined via $MC_CHAN_NAME can also be programmed (type: STRING).

⚠ CAUTION

Channel name

The names must not already exist in the NC with a different meaning, e.g. as key words, commands, axis names etc.

Note

Variables, which all channels can access (NCK-specific global variables), can be used for data exchange between programs. Otherwise separate programs must be written for each channel.

Examples

Example 1: Channel number assignment

Channel with the name "MACHINE" is to be assigned channel number 1, channel with the name "LOADER" is to be assigned channel number 2. The variables are given the same names as the channels:

```
DEF INT MACHINE=1, LOADER=2
```

The statement START is therefore:

```
START(MACHINE)
```

Example 2: Channel specification options

$MC_CHAN_NAME[0] = "CHAN_X" ; Name of the 1st channel
$MC_CHAN_NAME[1] = "CHAN_Y" ; Name of the 2nd channel

Programming with:

- Channel numbers:

Program code	Comment
START(1,2)	; Perform start in the 1st and 2nd channels.

- Channel identifiers:

Program code	Comment
START(CHAN_X, CHAN_Y)	; Perform start in the 1st and 2nd channels ; The channel_X and channel_Y identifiers represent channel numbers 1 and 2 internally, due to the $MC_CHAN_NAME machine data. They therefore also perform a start in the 1st and 2nd channel.

- Integer variables:

```
Program code                                    Comment
DEF INT chanNo1, chanNo2                        ; Define variables.
chanNo1=CHAN_X chanNo2=CHAN_Y
START(chanNo1, chanNo2)                         ; Perform start in the 1st and 2nd channels
```

Example 3: INIT command with absolute path specification

```
Program code
N10 INIT(2,"/_N_WKS_DIR/_N_SHAFT1_WPD/_N_CUT1_MPF")
```

Example 4: INIT command with relative path specification

```
Program code              Comment
N10 INIT(2,"MYPROG")      ; Select program /_N_MPF_DIR/_N_MYPROG_MPF in channel 2.
```

Example 5: Program coordination with WAITM

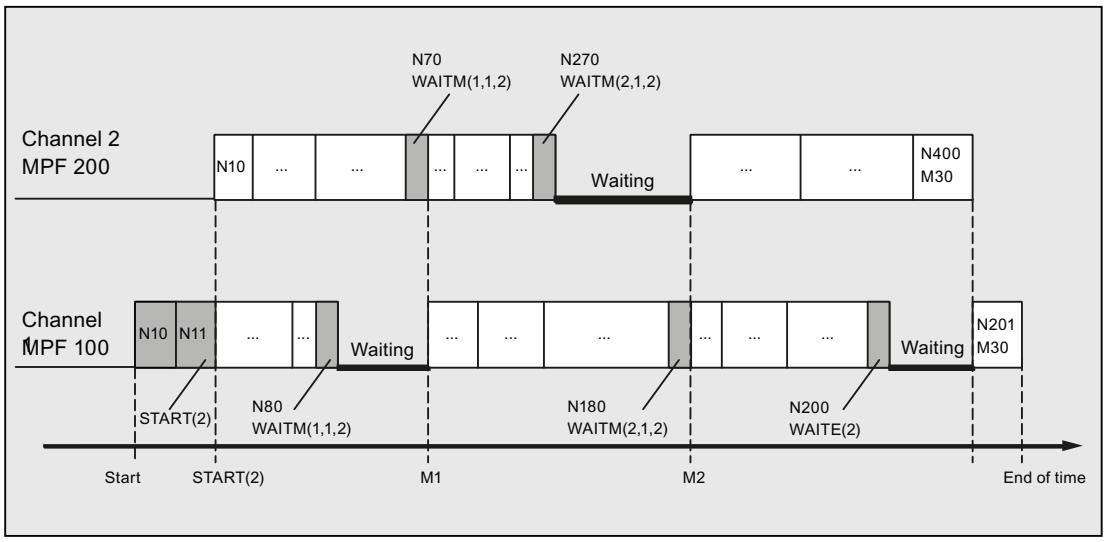
Channel 1: Program /_N_MPF_DIR/_N_MPF100_MPF is selected.

```
Program code                        Comment
N10 INIT(2,"MPF200","N")
N11 START(2)
...                                 ; Processing in channel 1
N80 WAITM(1,1,2)                    ; Wait until wait marker 1 is reached in channels 1
                                      and 2.
...                                 ; Additional processing in channel 1.
N180 WAITM(2,1,2)                   ; Wait until wait marker 2 is reached in channels 1
                                      and 2.
...                                 ; Additional processing in channel 1.
N200 WAITE(2)                       ; Wait for the end of program of channel 2
N201 M30                            ; End of program of channel 1, total end.
```

Channel 2: The INIT command (see N10 in _N_MPF100_MPF) selects the _N_MPF200_MPF program for execution in channel 2.

```
Program code          Comment
;$PATH=/_N_MPF_DIR
...                   ; Processing in channel 2
```

```
Program code              Comment
N70 WAITM(1,1,2)          ; Wait until wait marker 1 is reached in channels 1 and 2.
...                       ; Additional processing in channel 2.
N270 WAITM(2,1,2)         ; Wait until wait marker 2 is reached in channels 1 and 2.
...                       ; Additional processing in channel 2.
N400 M30                  ; End of program in channel 2.
```



1.14 Interrupt routine (ASUB)

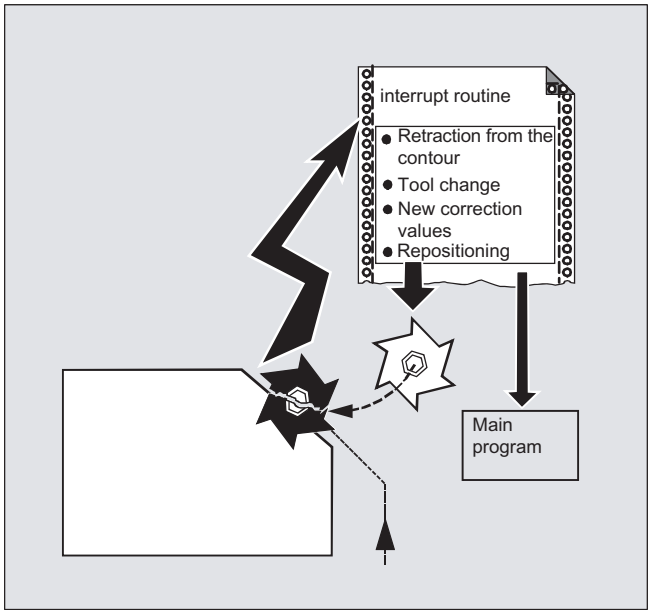
1.14.1 Function of an interrupt routine

Note

The terms "asynchronous subprogram (ASUB)" and "interrupt routine" are used interchangeably in the description below to refer to the same functionality.

Function

A typical example should clarify the function of an interrupt routine:



The tool breaks during machining. This triggers a signal that stops the current machining process and simultaneously starts a subprogram – the so-called interrupt routine. The interrupt routine contains all the statements which are to be executed in this case.

When the interrupt routine execution has finished and the machine is ready to continue operation, the control jumps back to the main program and continues machining at the point of interruption – depending on the REPOS command (see "Repositioning at contour (Page 476)").

⚠CAUTION

Risk of collision

If a REPOS command has not been programmed in the subprogram, then the control goes to the end point of the block that follows the interrupted block.

References

Function Manual, Basic Functions; Mode Group, Channel, Program Operation, Reset Response (K1), Section: "Asynchronous subprograms (ASUBs), interrupt routines"

1.14.2 Creating an interrupt routine

Create interrupt routine as subprogram

The interrupt routine is identified as a subprogram in the definition.

Example:

```
Program code        Comment
PROC LIFT_Z         ; Program name "ABHEB_Z"
N10 ...             ; The NC blocks then follow:
...
N50 M17             ; At the end, the end of the program and return to the main
                      program.
```

Save modal G functions (SAVE)

The interrupt routine can be designated by defining with SAVE.

The SAVE attribute means that the active modal G functions saved before calling the interrupt routine and are re-activated after the end of the interrupt routine (see "Subprograms with SAVE mechanism (SAVE) (Page 166)").

This means that it is possible to resume processing at the interruption point after the interrupt routine has been completed.

Example:

```
Program code
PROC LIFT_Z SAVE
N10 ...
...
N50 M17
```

Assign additional interrupt routines (SETINT)

SETINT instructions can be programmed within the interrupt routine (see "Assign and start interrupt routine (SETINT)" (Page 124)) therefore activating additional interrupt routines. They are triggered via the input.

References

You will find more information on how to create subprograms in Section "Subprograms, Macros".

1.14.3 Assign and start interrupt routine (SETINT, PRIO, BLSYNC)

Function

The control has signals (inputs 1...8) that initiate that the program being executed is interrupted and a corresponding interrupt routine can be started.

The assignment as to which input starts which program is realized in the part program using the SETINT command.

If several SETINT instructions are in the part program and therefore several signals can be simultaneously received, the assigned interrupt routines must be allocated priorities that define the sequence in which the interrupt routines are executed: PRIO=<value>

If new signals are received while interrupt routines are being executed, the current interrupt routines are interrupted by routines with higher priority.

Syntax

```
SETINT(<n>) PRIO=<value> <NAME>
SETINT(<n>) PRIO=<value> <NAME> BLSYNC
SETINT(<n>) PRIO=<value> <NAME> LIFTFAST
```

Meaning

SETINT(<n>):	Command: Assign input <n> to an interrupt routine. The assigned interrupt routine starts when input <n> switches. **Note:** If an input that is already assigned is allocated to a new routine, then the old assignment is automatically cancelled.
<n>:	Parameters: Input number Type: INT Range of values: 1 ... 8
PRIO= :	Command: Defining the priority
<value>:	Priority value Type: INT Range of values: 1 ... 128 Priority 1 corresponds to the highest priority.
<NAME>:	Name of the subprogram (interrupt routine) that is to be executed.
BLSYNC:	If the SETINT operation is programmed together with BLSYNC, when the interrupt signal is received the program block which is in progress will continue to be processed; only once this is complete will the interrupt routine be launched.
LIFTFAST:	If the SETINT operation is programmed together with LIFTFAST, when the interrupt signal is received a "fast retraction of the tool from the contour" will be performed before the start of the interrupt routine (see "Fast retraction from the contour (SETINT LIFTFAST, ALF) (Page 127)").

Examples

Example 1: Assign interrupt routines and define the priority

```
Program code                                Comment
...
N20 SETINT(3) PRIO=1 ABHEB_Z                ; If input 3 switches, then interrupt routine
                                              "ABHEB_Z" should start.
N30 SETINT(2) PRIO=2 ABHEB_X                ; If input 2 switches, then interrupt routine
                                              "ABHEB_X" should start.
...
```

The interrupt routines are executed in the sequence of the priority values if the inputs become available simultaneously (are energized simultaneously): First "ABHEB_Z", the "ABHEB_X".

Example 2: Newly assign an interrupt routine

```
Program code                                Comment
...
N20 SETINT(3) PRIO=2 ABHEB_Z                ; If input 3 switches, then interrupt routine
                                              "ABHEB_Z" should start.
…
N120 SETINT(3) PRIO=1 ABHEB_X               ; Input 3 is assigned to a new interrupt
                                              routine: Instead of "ABHEB_Z", "ABHEB_X"
                                              should start if input 3 switches.
```

1.14.4 Deactivating/reactivating the assignment of an interrupt routine (DISABLE, ENABLE)

Function

A SETINT instruction can be deactivated with DISABLE and reactivated with ENABLE without losing the input → interrupt routine assignment.

Syntax

```
DISABLE(<n>)
ENABLE(<n>)
```

Meaning

DISABLE(<n>):	Command: **Deactivating** the interrupt routine assignment of input <n>
ENABLE(<n>):	Command: **Reactivating** the interrupt routine assignment of input <n>
<n>:	Parameter: Input number
	Type: INT
	Range of values: 1 ... 8

Example

Program code	Comment
...	
N20 SETINT(3) PRIO=1 ABHEB_Z	; If input 3 switches, then interrupt routine "ABHEB_Z" should start.
...	
N90 DISABLE(3)	; The SETINT instruction from N20 is deactivated.
...	
N130 ENABLE(3)	; The SETINT instruction from N20 is reactivated.
...	

1.14.5 Delete assignment of interrupt routine (CLRINT)

Function

An input → interrupt routine defined using `SETINT` can be deleted with `CLRINT`.

Syntax

`CLRINT(<n>)`

Meaning

`CLRINT(<n>)`: Command: Deleting the interrupt assignment of input <n>

`<n>`: Parameter: Input number

Type: INT

Range of values: 1 ... 8

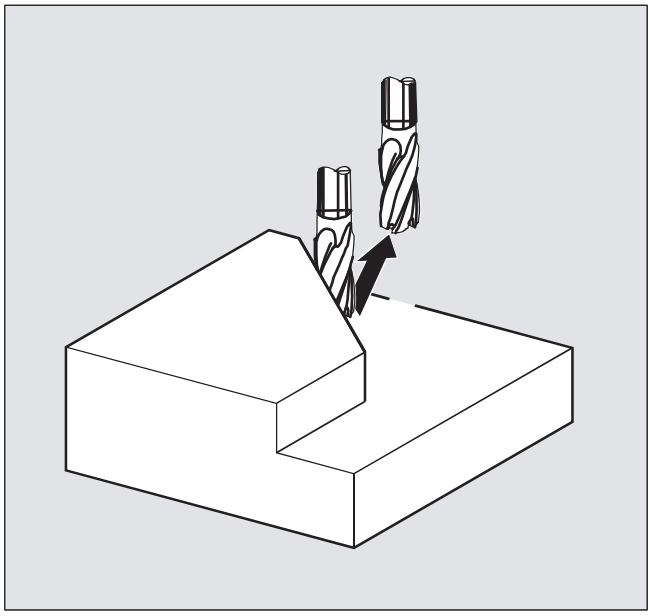
Example

Program code	Comment
...	
N20 SETINT(3) PRIO=2 ABHEB_Z	;
...	
N50 CLRINT(3)	; The assignment between input "3" and interrupt routine "ABHEB_Z" is deleted.
...	

1.14.6 Fast retraction from the contour (SETINT LIFTFAST, ALF)

Function

For a SETINT statement with LIFTFAST, when the input is switched, the tool is moved away from the workpiece contour using fast retraction.



The further sequence is then dependent on whether the SETINT statement includes an interrupt routine in addition to LIFTFAST:

With interrupt routine:	**After** the fast retraction, the interrupt routine is executed.
Without interrupt routine:	Machining is stopped after fast retraction and an alarm is output.

Syntax

```
SETINT(<n>) PRIO=1 LIFTFAST
SETINT(<n>) PRIO=1 <NAME> LIFTFAST
```

Meaning

SETINT(<n>):	Command: Assign input <n> to an interrupt routine. The assigned interrupt routine starts when input <n> switches.
<n>:	Parameter: Input number Type: INT Range of values: 1 ... 8
PRIO= :	Defining the priority

<value>:	Priority value Range of values: 1 ... 128 Priority 1 corresponds to the highest priority.
<NAME>:	Name of the subprogram (interrupt routine) that is to be executed.
LIFTFAST:	Command: Fast retraction from the contour
ALF=… :	Command: Programmable traverse direction (in motion block) Regarding the possibilities of programming with ALF, refer to the subject "Traversing direction for fast retraction from the contour (Page 129)".

Supplementary conditions

Behavior for active frame with mirroring

When determining the retraction direction, a check is performed to see whether a frame with mirror is active. In this case, for the retraction direction, right and left are interchanged referred to the tangential direction. The direction components in tool direction are not mirrored. This behavior is activated with using the MD setting:

MD21202 $MC_LIFTFAST_WITH_MIRROR = TRUE

Example

A broken tool should be automatically replaced by a daughter tool. Machining is then continued with the new tool.

Main program:

Main program	Comment
N10 SETINT(1) PRIO=1 W_WECHS LIFTFAST	; When input 1 is switched, the tool is immediately retracted from the contour with fast retraction (code No. 7 for tool radius compensation G41). Then interrupt routine "W_WECHS" is executed.
N20 G0 Z100 G17 T1 ALF=7 D1	
N30 G0 X-5 Y-22 Z2 M3 S300	
N40 Z-7	
N50 G41 G1 X16 Y16 F200	
N60 Y35	
N70 X53 Y65	
N90 X71.5 Y16	
N100 X16	
N110 G40 G0 Z100 M30	

Subprogram:

Subprogram	Comment
PROC W_CHANGE SAVE	; Subprogram where the actual operating state is saved
N10 G0 Z100 M5	; Tool changing position, spindle stop
N20 T11 M6 D1 G41	; Change tool
N30 REPOSL RMBBL M3	; Reposition at the contour and return jump into the main program (this is programmed in a block)

1.14.7 Traversing direction for fast retraction from the contour

Retraction movement

The following G code defines the retraction movement plane:

- LFTXT

  The retraction movement plane is defined by the path tangent and the tool direction (default setting).

- LFWP

  The plane of the retraction movement is the active working plane selected with G codes G17, G18 or G19. The direction of the retraction movement is not dependent on the path tangent. This allows a fast retraction to be programmed parallel to the axis.

- LFPOS

  Retraction of the axis declared using POLFMASK/POLFMLIN to the absolute axis position programmed with POLF.

  ALF has no influence on the retraction direction for several axes and for several axes in a linear system.

  References:
  Programming Manual, Fundamentals, Section: "Rapid retraction during thread cutting"

Programmable traversing direction (ALF=…)

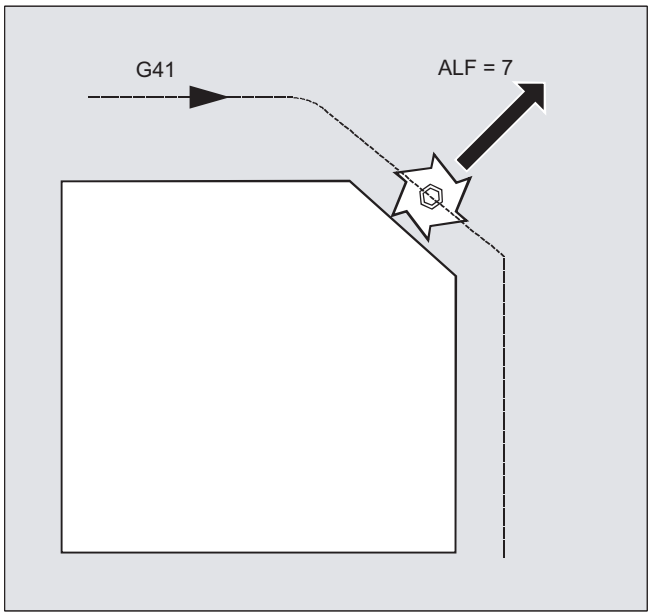
The direction is programmed in discrete steps of 45 degrees with ALF in the plane of the retraction movement.

The possible traversing directions are stored in special code numbers on the control and can be called up using these numbers.

Example:

```
Program code
N10 SETINT(2) PRIO=1 ABHEB_Z LIFTFAST
ALF=7
```

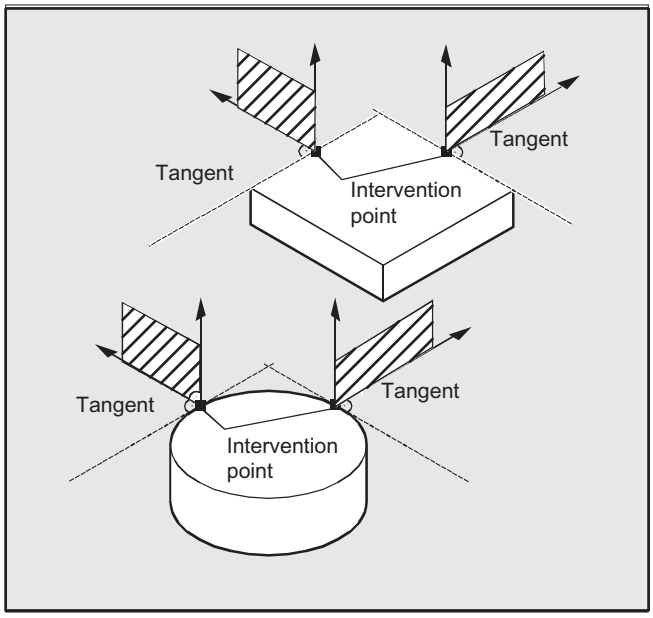
With `G41` activated (machining direction to the left of the contour) the tool vertically moves away from the contour.



Reference plane for defining the traversing direction for LFTXT

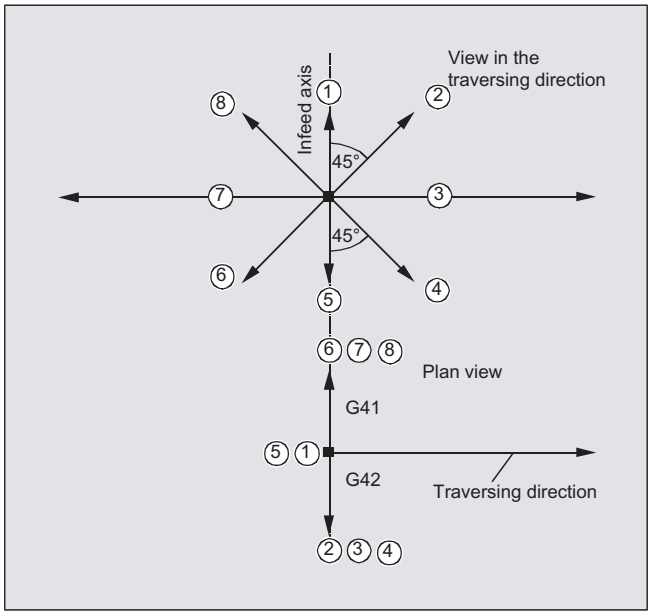
At the point of application of the tool to the programmed contour, the tool is clamped at a plane which is used as a reference for specifying the retraction movement with the corresponding code number.

The reference plane is derived from the longitudinal tool axis (infeed direction) and a vector positioned perpendicular to this axis and perpendicular to the tangent at the point of application of the tool.



Code numbers with traversing direction for LFTXT

Starting from the reference plane, you will find the code numbers with traversing directions in the following diagram.



The retraction in the tool direction is defined for `ALF=1`.

The "fast retraction" function is deactivated with `ALF=0`.

⚠ CAUTION

Risk of collision

When the tool radius compensation is activated, then:

- For `G41` codes 2, 3, 4
- For `G42` codes 6, 7, 8

should not be used, as in these cases, the tool would move to the contour and would collide with the workpiece.

Code numbers with traversing directions for LFWP

With `LFWP` the direction in the working plane is derived from the following assignment:

- `G17`: X/Y plane

  `ALF=1`: Retraction in the X direction

  `ALF=3`: Retraction in the Y direction

- `G18`: Z/X plane

  `ALF=1`: Retraction in the Z direction

  `ALF=3`: Retraction in the X direction

- `G19`: Y/Z plane

  `ALF=1`: Retraction in the Y direction

  `ALF=3`: Retraction in the Z direction

1.14.8 Motion sequence for interrupt routines

Interrupt routine without LIFTFAST

Axis motion is braked along the path down to standstill (zero speed). The interrupt routine then starts.

The standstill position is saved as interrupt position and is approached at the end of the interrupt routine for REPOS with RMIBL.

Interrupt routine with LIFTFAST

Axis motion is braked along the path. The LIFTFAST motion is simultaneously executed as superimposed motion. If the path motion and LIFTFAST motion have come to a standstill (zero speed), the interrupt routine is started.

The position on the contour is saved as interrupt position where the LIFTFAST motion is started and therefore the path was left.

The interrupt routine with LIFTFAST and ALF=0 behaves in precisely the same way as the interrupt routine without LIFTFAST.

Note

The absolute value through which the geometry axes move when quickly retracting from the contour can be set using machine data.

1.15 Axis replacement, spindle replacement (RELEASE, GET, GETD)

Function

One or more axes or spindles can only ever be interpolated in one channel. If an axis has to alternate between two different channels (e.g. pallet changer) it must first be enabled in the current channel and then transferred to the other channel. Axis replacement is effective between channels.

Axis replacement extensions

An axis/spindle can be replaced either with a preprocessing stop and synchronization between preprocessing and main run, or without a preprocessing stop. Axis replacement is also possible via:

- Axis container rotation AXCTSWE or AXCTWED using implicit GET/GETD
- Frame with rotation if this process links the axis with other axes.
- Synchronized actions, see Motion-synchronous actions, "Axis replacement RELEASE, GET".

Machine manufacturer

Please refer to the machine manufacturer's instructions. For the purpose of axis replacement, one axis must be defined uniquely in all channels in the configurable machine data and the axis replacement characteristics can also be set using machine data.

Syntax

`RELEASE (axis name, axis name, ...)` or `RELEASE (S1)`

`GET (axis name, axis name, ...)` or `GET (S2)`

`GETD(axis name, axis name, ...)` or `GETD(S3)`

With GETD (GET Directly), an axis is fetched directly from another channel. This means that no suitable RELEASE must be programmed for this GETD in another channel. It also means that other channel communication has to be established (e.g. wait markers).

Meaning

`RELEASE (axis name, axis name, etc.)`:	Release the axis (axes)
`GET (axis name, axis name, etc.)`:	Accept the axis (axes)
`GETD (axis name, axis name, etc.)`:	Directly accept the axis (axes)
`Axis name`:	Axis assignment in the system: AX1, AX2, ... or specify machine axis name
`RELEASE(S1)` :	Release spindles S1, S2, ...
`GET(S2)` :	Accept spindles S1, S2, ...
`GETD(S3)` :	Direct acceptance of spindles S1, S2, ...

GET request without preprocessing stop

If, following a GET request **without** preprocessing stop, the axis is enabled again with `RELEASE(axis)` or `WAITP(axis)`, a subsequent `GET` will induce a `GET` **with** preprocessing stop.

⚠ CAUTION

Axis assignment changed

An axis or spindle accepted with GET remains assigned to this channel even after a key or program RESET.

When a program is restarted the replaced axes or spindles must be reassigned in the program if the axis is required in its original channel.

It is assigned to the channel defined in the machine data on POWER ON.

Examples

Example 1: Axis exchange between two channels

Of the six axes, the following are used for machining in channel 1: 1st, 2nd, 3rd and 4th axis. The 5th and 6th axes in channel 2 are used for the workpiece change.

Axis 2 should be exchanged between two channels and after POWER ON can be assigned to channel 1.

Program "MAIN" in channel 1:

```
Program code                    Comment
INIT (2,"TRANSFER2")            ; Select program TRANSFER2 in channel 2.
N… START (2)                    ; Start the program in channel 2.
N… GET (AX2)                    ; Accept axis AX2.
...
N… RELEASE (AX2)                ; Release axis AX2.
N… WAITM (1,1,2)                ; Wait for WAIT marker in channel 1 and 2 for
                                synchronizing in both channels.
...                             ; Rest of program after axis replacement.
N… M30
```

Program "TRANSFER2" in channel 2:

```
Programming                     Comment
N… RELEASE (AX2)
N160 WAITM(1,1,2)               ; Wait for WAIT marker in channel 1 and 2 for
                                synchronizing in both channels.
N150 GET(AX2)                   ; Accept axis AX2.
...                             ; Rest of program after axis replacement.
N… M30
```

Example 2: Axis exchange without synchronization

If the axis does not have to be synchronized no preprocessing stop is generated by GET.

```
Programming                     Comment
N01 G0 X0
N02 RELEASE(AX5)
N03 G64 X10
N04 X20
N05 GET(AX5)                    ; If synchronization is not required, then this is
                                not a block that can be executed.
N06 G01 F5000                   ; Block that cannot be executed.
N07 X20                         ; Block that cannot be executed, as X position as in N04.
N08 X30                         ; First block that can be executed after N05.
...
```

Example 3: Activating an axis exchange without a preprocessing stop

Requirement: Axis replacement without a preprocessing stop must be configured via machine data.

```
Programming                    Comment
N010 M4 S100
N011 G4 F2
N020 M5
N021 SPOS=0
N022 POS[B]=1
N023 WAITP(B)                  ; Axis B becomes the neutral axis.
N030 X1 F10
N031 X100 F500
N032 X200
N040 M3 S500                   ; Axis does not trigger a preprocessing stop / REORG
N041 G4 F2
N050 M5
N099 M30
```

If the spindle or axis B is traversed, e.g. to 180 degrees and then back to 1 degree immediately after block N023 as the **PLC axis**, this axis will revert to its neutral status and will not trigger a preprocessing stop in block `N40`.

Requirement

Requirements for axis replacement

- The axis must be defined in all channels that use the axis in the machine data.
- It is necessary to define to which channel the axis will be assigned after POWER ON in the **axis**-specific machine data.

Description

Release axis: RELEASE

When enabling the axis please note:

1. The axis must not be involved in a transformation.
2. All the axes involved in an axis link (tangential control) must be enabled.
3. A concurrent positioning axis cannot be replaced in this situation.
4. All the following axes of a gantry master axis are transferred with the master.
5. With coupled axes (coupled motion, master value coupling, electronic gear) only the leading axis of the group can be enabled.

Accept axis: GET

The actual axis replacement is performed with this command. The channel for which the command is programmed takes full responsibility for the axis.

Effects of GET:

Axis replacement with synchronization:

An axis always has to be synchronized if it has been assigned to another channel or the PLC in the meantime and has not been resynchronized with "WAITP", G74 or delete distance-to-go before GET.

- A preprocess stop follows (as for STOPRE).
- Execution is interrupted until the replacement has been completed.

Automatic "GET"

If an axis is in principle available in a channel but is not currently defined as a "channel axis", GET is executed automatically. If the axis/axes is/are already synchronized no preprocess stop is generated.

Varying the axis replacement behavior

The transfer point of axes can be set as follows using machine data:

- Automatic axis replacement between two channels then also takes place when the axis has been brought to a neutral state by WAITP (response as before)
- When requesting an axis container rotation, all axes of the axis container which can be assigned to the executing channel are brought into the channel using implicit GET or GETD. A subsequent axle replacement is only permitted again once the axis container rotation has been completed.
- When an intermediate block is inserted in the main run, a check will be made to determine whether or not reorganization is required. Reorganization is only necessary if the axis states of this block do **not** match the current axis states.
- Instead of a GET block with preprocessing stop and synchronization between preprocessing and main run, axes can be replaced without a preprocessing stop. In this case, an intermediate block is simply generated with the GET request. In the main run, when this block is executed, the system checks whether the states of the axes in the block match the current axis states.

For more information about how axis or spindle replacement works, see
Function Manual, Extended Functions, Mode Groups, Channels, Axis Replacement (K5).

1.16 Transfer axis to another channel (AXTOCHAN)

Function

The AXTOCHAN language command can be used to request an axis in order to move it to a different channel. The axis can be moved to the corresponding channel both from the NC part program and from a synchronized action.

Syntax

```
AXTOCHAN(axis name,channel number[,axis name,channel number[,...]])
```

Meaning

Element	Description
AXTOCHAN:	Request axis for a specific channel
Axis name:	Axis assignment in the system: X, Y, … or entry of machine axis names concerned. The executing channel does not have to be the same channel or even the channel currently in possession of the interpolation right for the axis.
Channel number:	Name of the channel to which the axis is to be assigned

Note

Competing positioning axis and PLC controlled axis exclusively

A PLC axis cannot replace the channel as a competing positioning axis. An axis controlled exclusively by the PLC cannot be assigned to the NC program.

References:
Function Manual, Extended Functions; Positioning Axes (P2)

Example

AXTOCHAN in the NC program

Axes X and Y have been declared in the first and second channels. Currently, channel 1 has the interpolation right and the following program is started in that channel.

```
Program code                    Comment
N110 AXTOCHAN(Y,2)              ; Move Y axis to second channel.
N111 M0
N120 AXTOCHAN(Y,1)              ; Retrieve Y axis (neutral).
N121 M0
N130 AXTOCHAN(Y,2,X,2)          ; Move Y axis and X axis to second channel (axes are
                                  neutral).
```

```
Program code                    Comment
N131 M0
N140 AXTOCHAN(Y,2)              ; Move Y axis to second channel (NC program).
N141 M0
```

Further information

AXTOCHAN in the NC program

A GET is only executed in the event of the axis being requested for the NC program in the same channel (this means that the system waits for the state to actually change). If the axis is requested for another channel or is to become the neutral axis in the same channel, the request is sent accordingly.

AXTOCHAN from a synchronized action

In the event of an axis being requested for the same channel, AXTOCHAN from a synchronized action is mapped to a GET from a synchronized action. In this case, the axis becomes the neutral axis on the first request for the same channel. On the second request, the axis is assigned to the NC program in the same way as the GET request in the NC program. For more information about GET requests from a synchronized action, see "Motion-synchronous actions".

1.17 Activate machine data (NEWCONF)

Function

The NEWCONF command is used to set all machine data of the "NEW_CONFIG" effectiveness level active. The function can also be activated in the HMI user interface by pressing the "MD data effective" softkey.

When the "NEWCONF" function is executed there is an implicit preprocessing stop; in other words, path movement is interrupted.

Syntax

```
NEWCONF
```

Meaning

NEWCONF: Command for setting all machine data of the "NEW_CONFIG" effectiveness level active

Cross-channel execution of NEWCONF from the part program

If changes are made to axial machine data from the part program and then activated with NEWCONF, NEWCONF will only activate the machine data containing changes affecting the part program channel.

Note

In order to ensure that all changes are applied, the NEWCONF command must be executed in every channel in which the axes or functions affected by the changes to the machine data is being calculated.

No axial machine data is effective for NEWCONF.

An axial RESET must be performed for axes controlled by the PLC.

Example

Milling: Machine drill position with different technologies

```
Program code                          Comment
N10 $MA_CONTOUR_TOL[AX]=1.0           ; Change machine data.
N20 NEWCONF                           ; Activate machine data.
...
```

1.18 Write file (WRITE)

Function

Using the WRITE command, sets/data can be written from the NC program to the end of a specified file in the passive file system (log file). This can also be the program that is presently being executed.

Note

If no such file exists in the NC, one will be created and can be written to using the WRITE command.

The storage location is the static NC memory. In the case of SINUMERIK 840D sl this is the CompactFlash card. Unlike SINUMERIK 840D this increases the runtime of the WRITE command by approx. 75 ms.

If a file with the same name exists on the hard disk, it is overwritten after the file is closed (in the NC). Remedy: Change the file name in the NC via the user interface.

Further, using the WRITE command, it is also possible to write data from an NC program to an external device/external file (also see "Process DataShare - output to an external device/file (EXTOPEN, WRITE, EXTCLOSE) (Page 605)").

Requirement

The currently set protection level must be equal to or greater than the WRITE right of the file. If this is not the case, access is denied with an error message (return value of error variable = 13).

Syntax

```
DEF INT <error>
...
WRITE(<error>,"<file name>"/"<ExtG>","<set/data>")
```

Meaning

`WRITE`: Command for appending a block or data to the end of the specified file.

`<error>`: **Parameter 1:** Variable for returning the error value

Type: INT

Value:

0	No error
1	Path not allowed
2	Path not found
3	File not found
4	Incorrect file type
10	File is full
11	The file is in use
12	No resources available
13	No access rights
14	missing or unsuccessful EXTOPEN for the output device
15	Error when writing to an external device
16	Invalid external path has been programmed

<file name>: **Parameter 2:** The name of the file in the passive file system in which the specified block or specified data is to be added.

Type: STRING

The following points should be noted when specifying the file name:

- The specified file name must not contain any blank spaces or control characters (characters with ASCII code ≤ 32), otherwise the WRITE command will be canceled with error code 1 "Path not allowed".
- The file name can be specified with path data and file identifier.
  - Path data

    Path data must be absolute, i.e. start with "/".

    If a path is not specified, the file is saved in the current directory (= directory of selected program).
  - File identifier

    If the file name does not contain a domain identifier ("_N_"), it is added accordingly.

    If the fourth-last character of the file name is an underscore "_", the next three characters will be interpreted as the file identifier. In order to be able to use the same file name for all file commands, e.g. via a STRING type variable, only the _SPF and _MPF file identifiers may be used.

    If there is no "_MPF" or "_SPF" identifier, the file name is automatically completed with _MPF.
- The file name length can be up to 32 bytes, the path length up to 128 bytes.

Example:

```
"PROTFILE"
"_N_PROTFILE"
"_N_PROTFILE_MPF"
"/_N_MPF_DIR_/_N_PROTFILE_MPF/"
```

<ExtG>: If the data is to be output to an external device/file, then the symbolic identifiers for the external device/file to be opened must be specified instead of the file name.

Type: STRING

For further information, see "Process DataShare - output to an external device/file (EXTOPEN, WRITE, EXTCLOSE) (Page 605)".

Note:
The identifier must be identical to the identifier specified in the EXTOPEN command.

<block/data>: The block or data to be added to the specified file.

Type: STRING

Note

When writing into the passive file system of the NCK, the WRITE command implicitly inserts an "LF" character (LINE FEED = new line) at the end of the output string.

This behavior does not apply for output on an external device/file. If an "LF" is also to be output, then this must be explicitly specified in the output string.

→ also refer to example 3: Implicit/explicit "LF"!

Supplementary conditions

- **Maximum file size (→ machine manufacturer)**

  The maximum possible file size of log files in the passive file system is set with the machine data:

  MD11420 $MN_LEN_PROTOCOL_FILE

  The maximum file length is applicable for all files created using the WRITE command in the passive file system. If it is exceeded an error message is output and the block or data is not saved. If there is sufficient free memory, a new file can be created.

Examples

Example 1: WRITE command into the passive file system without absolute path data

```
Program code                                                    Comment
N10 DEF INT ERROR                                               ; Definition of error
                                                                  variables.
N20 WRITE(ERROR,"PROT","LOG FROM 7.2.97")                       ; Write the text from "LOG
                                                                  FROM 7.2.97" to file
                                                                  _N_PROT_MPF.
N30 IF ERROR                                                    ; Error evaluation.
N40 MSG ("Error with WRITE command:" <<ERROR)
N50 M0
N60 ENDIF
...
```

Example 2: WRITE command into the passive file system with absolute path data

```
Program code
...
WRITE(ERROR,"/_N_WKS_DIR/_N_PROT_WPD/_N_PROT_MPF","LOG FROM 7.2.97")
...
```

Example 3: Implicit/explicit "LF"

a, writing into the passive file system with implicitly generated "LF"

Program code

```
...
N110 DEF INT ERROR
N120 WRITE(ERROR,"/_N_MPF_DIR/_N_MYPROTFILE_MPF","MY_STRING")
N130 WRITE(ERROR,"/_N_MPF_DIR/_N_MYPROTFILE_MPF","MY_STRING")
N140 M30
```

Output result:

MY_STRING

MY_STRING

b, writing into an external file without implicitly generated "LF"

Program code

```
...
N200 DEF STRING[30] DEV_1
N210 DEF INT ERROR
N220 DEV_1="LOCAL_DRIVE/myprotfile.mpf"
N230 EXTOPEN(ERROR,DEV_1)
N240 WRITE(ERROR,DEV_1,"MY_STRING")
N250 WRITE(ERROR,DEV_1,"MY_STRING")
N260 EXTCLOSE(ERROR,DEV_1)
N270 M30
```

Output result:

MY_STRINGMY_STRING

c, writing into an external file with explicitly generated "LF"

The following must be programmed in order to achieve the same result as under a:

Program code

```
...
N200 DEF STRING[30] DEV_1
N210 DEF INT ERROR
N220 DEV_1="LOCAL_DRIVE/myprotfile.mpf"
N230 EXTOPEN(ERROR,DEV_1)
N240 WRITE(ERROR,DEV_1,"MY_STRING'H0A'")
N250 WRITE(ERROR,DEV_1,"MY_STRING'H0A'")
N260 EXTCLOSE(ERROR,DEV_1)
N270 M30
```

Output result:

MY_STRING

MY_STRING

See also

Process DataShare - output to an external device/file (EXTOPEN, WRITE, EXTCLOSE) (Page 605)

1.19 Delete file (DELETE)

Function

The DELETE command can be used to delete all files, irrespective of whether these were created using the WRITE command or not. Files that were created using a higher access authorization can also be deleted with DELETE.

Syntax

```
DEF INT <error>
DELETE(<error>,"<file name>")
```

Meaning

DELETE:	Command for deleting the specified file.		
<error>:	Variable for returning the error value.		
	Type.	INT	
	Value:	0	No error
		1	Path not allowed
		2	Path not found
		3	File not found
		4	Incorrect file type
		11	The file is in use
		12	No resources available
		20	Other error

<file name>: Name of the file to be deleted

Type: STRING

The following points should be noted when specifying the file name:

- The specified file name must not contain any blank spaces or control characters (characters with ASCII code ≤ 32), otherwise the DELETE command will be canceled with error code 1 "Path not allowed".
- The file name can be specified with path data and file identifier.
  - Path data

    Path data must be absolute, i.e. start with "/".

    If a path is not specified, the file is searched for in the current directory (= directory of selected program).
  - File identifier

    If the file name does not contain a domain identifier ("_N_"), it is added accordingly.

    If the fourth-last character of the file name is an underscore "_", the next three characters will be interpreted as the file identifier. In order to be able to use the same file name for all file commands, e.g. via a STRING type variable, only the _SPF and _MPF file identifiers may be used.

    If there is no "_MPF" or "_SPF" identifier, the file name is automatically completed with _MPF.
- The file name length can be up to 32 bytes, the path length up to 128 bytes.

Example:

```
"PROTFILE"
"_N_PROTFILE"
"_N_PROTFILE_MPF"
"/_N_MPF_DIR_/_N_PROTFILE_MPF/"
```

Example

Program code	Comment
N10 DEF INT ERROR	; Definition of error variables.
N15 STOPRE	; Preprocessing stop.
N20 DELETE(ERROR,"/_N_SPF_DIR/_N_TEST1_SPF")	; Deletes file TEST1 in the subprogram directory.
N30 IF ERROR	; Error evaluation.
N40 MSG("error for DELETE command:" <<ERROR)	
N50 M0	
N60 ENDIF	

1.20 Read lines in the file (READ)

Function

The `READ` command reads one or several lines in the specified file and stores the information read in an STRING type array. In this array, each read line occupies an array element.

Note

The file must be stored in the NCK's static user memory (passive file system).

Requirement

The currently set protection level must be equal to or greater than the READ right of the file. If this is not the case, access is denied with an error message (return value of error variable = 13).

Syntax

```
DEF INT <error>
DEF STRING[<string length>] <result>[<n>,<m>]
READ(<error>,"<file name>",<start line>,<number of lines>,<result>)
```

Meaning

`READ`: Command for reading lines from the specified file and storing these lines in a variable array.

`<error>`: Variable for returning the error value (call-by-reference parameter)

Type. INT

Value:

0	No error
1	Path not allowed
2	Path not found
3	File not found
4	Incorrect file type
11	File is being used
13	Insufficient access rights
21	Line does not exist (`<start line>` or `<number of lines>` parameter exceeds the number of lines in the specified file).
22	Field length of the result variable (`<result>`) is too small.
23	Line range too large (`<number of lines>` parameter selected so large that the read would go beyond the end of the file).

`<file name>`: Name of the file to be read (call-by-value parameter)

Type: STRING

The following points should be noted when specifying the file name:

- The specified file name must not contain any blank spaces or control characters (characters with ASCII code ≤ 32), otherwise the `READ` command will be canceled with error code 1 "Path not allowed".
- The file name can be specified with path data and file identifier.
  - Path data

    Path data must be absolute, i.e. start with "/".

    If a path is not specified, the file is searched for in the current directory (= directory of selected program).
  - File identifier

    If the file name does not contain a domain identifier ("_N_"), it is added accordingly.

    If the fourth-last character of the file name is an underscore "_", the next three characters will be interpreted as the file identifier. In order to be able to use the same file name for all file commands, e.g. via a STRING type variable, only the _SPF and _MPF file identifiers may be used.

    If there is no "_MPF" or "_SPF" identifier, the file name is automatically completed with _MPF.
- The file name length can be up to 32 bytes, the path length up to 128 bytes.

Example:

```
"PROTFILE"
"_N_PROTFILE"
"_N_PROTFILE_MPF"
"/_N_MPF_DIR_/_N_PROTFILE_MPF/"
```

`<start line>`: Start line of the section of the file to be read (call-by-value parameter)

Type: INT

Value:		
	0	Reads the number of lines specified with the `<number of lines>` parameter before the end of the file.
	1 to n	Number of the first line to be read.

`<number of lines>`: Number of lines to be read (call-by-value parameter)

Type: INT

`<result>`: Result variable (call-by-reference parameter)

Variable array in which the read text is stored.

Type: STRING (max. length: 255)

If fewer lines are specified in the `<number of lines>` parameter than the array size `[<n>,<m>]` of the result variable, the remaining array elements will not be modified.

Termination of a line by means of the control characters "LF" (Line Feed) or "CR LF" (Carriage Return Line Feed) is **not** stored in the result variable.

Read lines are cropped if the line is longer than the defined string length. An error message is not output.

Note

Binary files cannot be read in. The "incorrect data type" error is output (return value of the error variable = 4). The following types of file are not readable: _BIN, _EXE, _OBJ, _LIB, _BOT, _TRC, _ACC, _CYC, _NCK.

Example

```
Program code                                                    Comment
N10 DEF INT ERROR                                               ;Definition of error variables.
N20 DEF STRING[255] RESULT[5]                                   ;Definition of result variables.
N30                                                             ;File name with domain and file identifier
READ(ERROR,"/_N_CST_DIR/_N_TESTFILE_MPF",1,5,RESULT)            ;and path name.
N40 IF ERROR <>0                                                ;Error evaluation.
N50 MSG("ERROR"<<ERROR<<"ON READ COMMAND")
N60 M0
N70 ENDIF
...
```

1.21 Check for presence of file (ISFILE)

Function

The `ISFILE` command can be used to check whether a file exists in the NCK's static user memory (passive file system).

Syntax

```
<result>=ISFILE("<file name>")
```

Meaning

`ISFILE`: Command for checking if the specified file exists in the passive file system.

`<file name>`: Name of the file whose existence is to be checked in the passive file system.

Type: STRING

The following points should be noted when specifying the file name:

- The specified file name must not contain any blank spaces or control characters (characters with ASCII code ≤ 32).
- The file name can be specified with path data and file identifier.
  - Path data

    Path data must be absolute, i.e. start with "/".

    If a path is not specified, the file is searched for in the current directory (= directory of selected program).
  - File identifier

    If the file name does not contain a domain identifier ("_N_"), it is added accordingly.

    If the fourth-last character of the file name is an underscore "_", the next three characters will be interpreted as the file identifier. In order to be able to use the same file name for all file commands, e.g. via a STRING type variable, only the _SPF and _MPF file identifiers may be used.

    If there is no "_MPF" or "_SPF" identifier, the file name is automatically completed with _MPF.
- The file name length can be up to 32 bytes, the path length up to 128 bytes.

Example:

```
"PROTFILE"
"_N_PROTFILE"
"_N_PROTFILE_MPF"
"/_N_MPF_DIR_/_N_PROTFILE_MPF/"
```

`<result>`: Result variable to which the result of the check is assigned.

Type. BOOL

Value:		
	TRUE	File exists
	FALSE	File does not exist

Example

Program code	Comment
N10 DEF BOOL RESULT	; Definition of result variables.
N20 RESULT=ISFILE("TESTFILE")	
N30 IF(RESULT==FALSE)	
N40 MSG("FILE DOES NOT EXIST")	
N50 M0	
N60 ENDIF	
...	

or:

Program code	Comment
N10 DEF BOOL RESULT	; Definition of result variables.
N20 RESULT=ISFILE("TESTFILE")	
N30 IF(NOT ISFILE("TESTFILE"))	
N40 MSG("FILE DOES NOT EXIST")	
N50 M0	
N60 ENDIF	
...	

1.22 Read out file information (FILEDATE, FILETIME, FILESIZE, FILESTAT, FILEINFO)

Function

The `FILEDATE`, `FILETIME`, `FILESIZE`, `FILESTAT`, and `FILEINFO` commands can be used to read out specific file information such as date/time of the last write access, current file size, file status or all of this information.

Note

The file must be stored in the NCK's static user memory (passive file system).

Requirement

The currently set protection level must be equal to or greater than the show right of the superordinate directory. If this is not the case, access is denied with an error message (return value of error variable = 13).

Syntax

```
FILE....(<error>,"<file name>",<result>)
```

Meaning

`FILEDATE`: Returns the **date** of the last write access to a file

`FILETIME`: Returns the **time** of the last write access to a file

`FILESIZE`: Returns the **current size** of a file

`FILESTAT`: Returns a file with regard to the following **rights** for the **status**:

- r: read
- w: write
- x: execute
- s: show
- d: delete

`FILEINFO`: Returns the **sum of the information** for a file that can be read out via `FILEDATE`, `FILETIME`, `FILESIZE` and `FILESTAT`

`<error>`: Variable for returning the error value (call-by-reference parameter)

Type. VAR INT

Value:

0	No error
1	Path not allowed
2	Path not found
3	File not found
4	Incorrect file type
13	Insufficient access rights
22	String length of the result variable (`<result>`) is too small.

`<file name>`: Name of the file from which the file information is to be read out

Type: CHAR[160]

The following points should be noted when specifying the file name:

- The specified file name must not contain any blank spaces or control characters (characters with ASCII code ≤ 32), otherwise the `FILE...` command will be canceled with error code 1 "Path not allowed".
- The file name can be specified with path data and file identifier.
  - Path data

    Path data must be absolute, i.e. start with "/".

    If a path is not specified, the file is searched for in the current directory (= directory of selected program).
  - File identifier

    If the file name does not contain a domain identifier ("_N_"), it is added accordingly.

    If the fourth-last character of the file name is an underscore "_", the next three characters will be interpreted as the file identifier. In order to be able to use the same file name for all file commands, e.g. via a STRING type variable, only the _SPF and _MPF file identifiers may be used.

    If there is no "_MPF" or "_SPF" identifier, the file name is automatically completed with _MPF.
- The file name length can be up to 32 bytes, the path length up to 128 bytes.

Example:

```
"PROTFILE"
"_N_PROTFILE"
"_N_PROTFILE_MPF"
"/_N_MPF_DIR_/_N_PROTFILE_MPF/"
```

`<result>`: Result variable (call-by-reference parameter)

Variable in which the requested file information is stored.

Type:			
	VAR CHAR[8]	at	FILEDATE Format: "dd.mm.yy"
	VAR CHAR[8]	at	FILETIME Format: "hh:mm.ss"
	VAR INT	at	FILESIZE The file size is output in bytes.
	VAR CHAR[5]	at	FILESTAT Format: "rwxsd" (r: **r**ead, w: **w**rite, x: e**x**ecute, s: **s**how, d: **d**elete)
	VAR CHAR[32]	at	FILEINFO Format: "rwxsd nnnnnnnn dd.mm.yy hh:mm:ss"

Example

```
Program code                                                    Comment
N10 DEF INT ERROR                                               ; Definition of error variables.
N20 STRING[32] RESULT                                           ; Definition of result variables.
N30 FILEINFO(ERROR,"/_N_MPF_DIR/_N_TESTFILE_MPF",RESULT)        ; Filename with domain, file
                                                                  identifier and path
                                                                  specification.
N40 IF ERROR <>0                                                ; Error evaluation
N50 MSG("ERROR"<<ERROR<<"ON FILEINFO COMMAND")
N60 M0
N70 ENDIF
...
```

The example could return the following result in the RESULT result variable, for example:

"77777 12345678 26.05.00 13:51:30"

1.23 Roundup (ROUNDUP)

Function

Input values, type REAL (fractions with decimal point) can be rounded up to the next higher integer number using the ROUNDUP" function.

Syntax

```
ROUNDUP(<value>)
```

Meaning

ROUNDUP:	Command to roundup an input value
<value>:	Input value, type REAL

Note

Input value, type INTEGER (an integer number) are returned unchanged.

Examples

Example 1: Various input values and their rounding up results

Example	Rounding up result
`ROUNDUP(3.1)`	4.0
`ROUNDUP(3.6)`	4.0
`ROUNDUP(-3.1)`	-3.0
`ROUNDUP(-3.6)`	-3.0
`ROUNDUP(3.0)`	3.0
`ROUNDUP(3)`	3.0

Example 2: ROUNDUP in the NC program

```
Program code
N10 X=ROUNDUP(3.5) Y=ROUNDUP(R2+2)
N15 R2=ROUNDUP($AA_IM[Y])
N20 WHEN X=100 DO Y=ROUNDUP($AA_IM[X])
...
```

1.24 Subprogram technique

1.24.1 General information

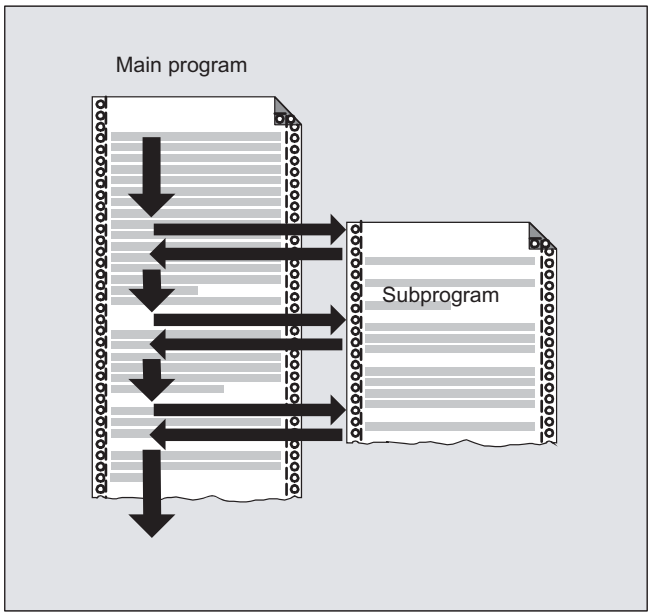
1.24.1.1 Subprogram

Function

The term "subprogram" has its origins during the time when part programs were split strictly into main and subprograms. Main programs were the part programs selected for processing on the controller and then launched. Subprograms were the part programs called from within the main program.

This strict division no longer exists with today's SINUMERIK NC language. In principle, each part program can be selected as a main program and launched or called from another part program as a subprogram.

Accordingly, the subprogram can then be used to refer to a part program called from within another part program.



Application

As in all high-level programming languages, in the NC language, subprograms are used to swap out program sections used more than once to independent, self-contained programs.

Subprograms offer the following advantages:

- Increase the transparency and readability of programs
- Increase quality by reusing tested program parts
- Offer the possibility of creating specific machining libraries
- Save memory space

1.24.1.2 Subprogram names

Naming rules

The following rules must be observed with regard to naming subprograms:

- The first two characters must be letters (A - Z, a - z).
- The following characters can be any combination of letters, numbers (0 to 9), and underscores ("_").
- A maximum of 31 characters may be used.

Note

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

Program name expansion

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

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

Using the program name

When using the program name, e.g. in the context of a subprogram call, all combinations of prefix, program name, and suffix are possible.

Example:

The subprogram with the program name "SUB_PROG" can be started using the following calls:

1. `SUB_PROG`
2. `_N_SUB_PROG`
3. `SUB_PROG_SPF`
4. `_N_SUB_PROG_SPF`

Note

Main programs and subprograms with the same name

If there are main programs (.MPF) and subprograms (.SPF) with the same program name, when the program name is used in the part program, the relevant suffix must be specified in order that the program can be uniquely identified.

1.24.1.3 Nesting of subprograms

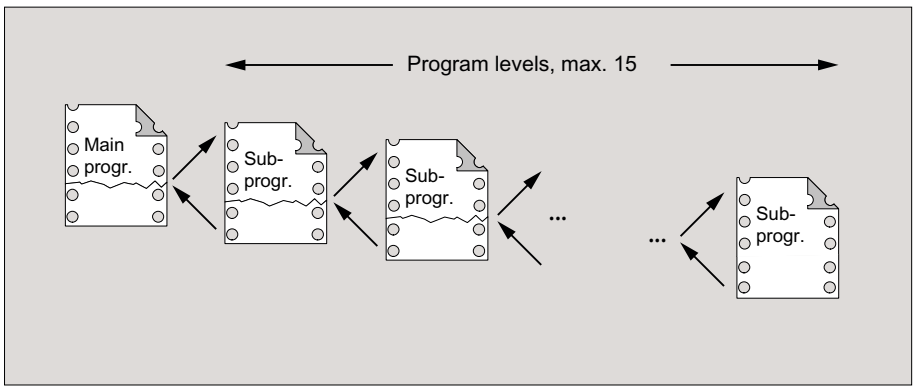
A main program can call subprograms which in turn call more subprograms. As such, the sequences of the programs are nested within each other. Each program runs on a dedicated program level.

Nesting depth

The NC language currently provides 16 program levels. The main program always runs at the uppermost program level, 0. A subprogram always runs at the next lowest program level following the call. Program level 1 is, therefore, the first subprogram level.

Division of program levels:

- Program level 0: Main program level
- Program level 1 to 15: Subprogram level 1 to 15



Interrupt routines (ASUB)

If a subprogram is called in the context of an interrupt routine, this will not be executed at the program level currently active in the channel (n) but at the next lowest program level (n+1). So that this remains possible even at the lowest program level, 2 additional program levels (16 and 17) are available in conjunction with interrupt routines.

If more than 2 program levels are required, this has to be taken into account explicitly in the structuring of the part program executed in the channel. In other words, only a maximum of as many program levels may be used in order to leave sufficient program levels available for interrupt processing.

If interrupt processing needs 4 program levels for example, the part program must be structured so that it uses a maximum of up to program level 13. In the event of an interrupt, the 4 program levels it requires (14 to 17) will be available to it.

Siemens cycles

Siemens cycles need 3 program levels. Therefore, a Siemens cycle must be called at the latest in:

- Part program processing: program level 12
- interrupt routine: program level 14

1.24.1.4 Search path

When a subprogram is called without a path being specified, the control will search the following directories in the sequence indicated:

Sequence	Directory	Description
1.	Current directory	Directory containing the calling program
2.	/_N_SPF_DIR /	Global subprogram directory

Sequence	Directory	Description
3.	/_N_CUS_DIR /	User cycles
4.	/_N_CMA_DIR /	Manufacturer cycles
5.	/_N_CST_DIR /	Standard cycles

1.24.1.5 Formal and actual parameters

Formal and actual parameters occur in conjunction with the definition and calling of subprograms with parameter transfer.

Formal parameter

When a subprogram is defined, the parameters to be transferred to it (known as the formal parameters) have to be defined with type and parameter name.

The formal parameters define, therefore, the interface of the subprogram.

Example:

```
Program code                              Comment
PROC CONTOUR (REAL X, REAL Y)             ; Formal parameters: X and Y, both REAL type
N20 X1=X Y1=Y                             ; Traversing of axis X1 to position X and axis
                                            Y1 to position Y
...
N100 RET
```

Actual parameters

When a subprogram is called, absolute values or variables (known as actual parameters) have to be transferred to it.

As such, the actual parameters assign up-to-date values to the interface of the subprogram when the latter is called.

Example:

```
Program code                              Comment
N10 DEF REAL WIDTH                        ; Variable definition
N20 WIDTH=20.0                            ; Variable assignment
N30 CONTOUR(5.5, WIDTH)                   ; Subprogram call with actual parameters: 5.5
                                            and WIDTH
...
N100 M30
```

1.24.1.6 Parameter transfer

Definition of a subprogram with parameter transfer

A subprogram with parameter transfer is defined using the PROC keyword and a complete list of all the parameters expected by the subprogram.

Incomplete parameter transfer

When the subprogram is called, not all the parameters defined in the subprogram interface have to be transferred explicitly. If a parameter is omitted, the default value "0" is transferred for it.

So that the parameter sequence can be uniquely identified, however, the commas used as parameter separators always have to be included. The last parameter is an exception. If it is omitted from the call, the last comma can also be left out.

Example:

Subprogram:

```
Program code                                    Comment
PROC SUB_PROG (REAL X, REAL Y, REAL Z)          ;  Formal parameters: X, Y, and Z
...
N100 RET
```

Main program:

```
Program code                        Comment
PROC MAIN_PROG
...
N30 SUB_PROG(1.0,2.0,3.0)           ; Subprogram call with complete parameter transfer:
                                      X=1.0, Y=2.0, Z=3.0
…
N100 M30
```

Examples for the subprogram call in N30 with incomplete parameter transfer:

```
N30 SUB_PROG( ,2.0,3.0)          ; X=0.0, Y=2.0, Z=3.0
N30 SUB_PROG(1.0, ,3.0)          ; X=1.0, Y=0.0, Z=3.0
N30 SUB_PROG(1.0,2.0)            ; X=1.0, Y=2.0, Z=0.0
N30 SUB_PROG( , ,3.0)            ; X=0.0, Y=0.0, Z=3.0
N30 SUB_PROG( , , )              ; X=0.0, Y=0.0, Z=0.0
```

NOTICE
Call-by-reference parameter transfer
Parameters transferred using call-by-reference must not be left out of the subprogram call.

NOTICE
AXIS data type
AXIS data type parameters must not be left out of the subprogram call.

Checking the transfer parameters

System variable $P_SUBPAR [n] where n = 1, 2, etc., can be used to check whether a parameter has been transferred explicitly or left out in the subprogram. The index n refers to the sequence of the formal parameters. Index n = 1 refers to the first formal parameter, index n = 2 to the second formal parameter, and so on.

The following program excerpt shows an example of how a check can be performed based on the first formal parameter:

```
Programming                                  Comment
PROC SUB_PROG (REAL X, REAL Y, REAL Z)       ; Formal parameters: X, Y, and Z
N20 IF $P_SUBPAR[1]==TRUE                    ; Check of the first formal parameter X.
...                                          ; These actions are taken if the formal
                                               parameter X has been transferred
                                               explicitly.
N40 ELSE
...                                          ; These actions are taken if the formal
                                               parameter X has not been transferred.
N60 ENDIF
...                                          ; General actions
N100 RET
```

1.24.2 Definition of a subprogram

1.24.2.1 Subprogram without parameter transfer

Function

When defining subprograms without parameter transfer, the definition line at the beginning of the program can be omitted.

Syntax

```
[PROC <program name>]
...
```

Significance

PROC:	Definition operation at the beginning of a program
<program name>:	Name of the program

Example

Example 1: Subprogram with PROC operation

Program code	Comment
PROC SUB_PROG	; Definition line
N10 G01 G90 G64 F1000	
N20 X10 Y20	
...	
N100 RET	; Subprogram return

Example 2: Subprogram without PROC operation

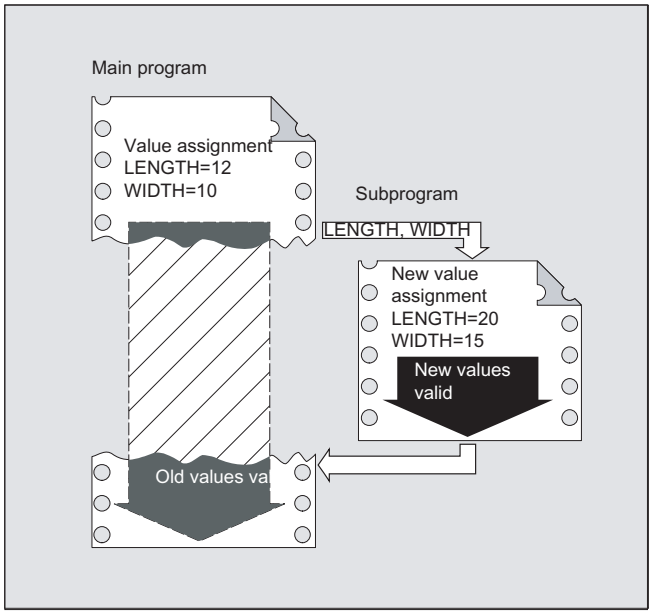
Program code	Comment
N10 G01 G90 G64 F1000	
N20 X10 Y20	
...	
N100 RET	; Subprogram return

1.24.2.2 Subprogram with call-by-value parameter transfer (PROC)

Function

A subprogram with call-by-value parameter transfer is defined using the PROC keyword followed by the name of the program and a complete list of all the parameters expected by the subprogram, with type and name. The definition operation must appear in the first program line.

Call-by-value parameter transfer does not affect the calling program. The calling program only transfers the values of the actual parameters to the subprogram.



Note

A maximum of 127 parameters can be transferred.

Syntax

```
PROC <prog_name> (<par_type> <par_1>[=<init_value_1>]{,
Par_2[=<init_value_1>]})
```

Meaning

PROC:	Definition operation at the beginning of a program
<prog_name>:	Name of the program
<par_type>:	Data type of the parameter (e.g. REAL, INT, BOOL)

<par_n>:	Name of the parameter
<init_value>:	Optional value for the initialization of the parameter If no parameter is specified when calling the subprogram, the parameter is assigned the initialization value.

Example

Definition of a subprogram SUB_PROG with three parameters of type REAL with default values:

Program code

```
PROC SUB_PROG(REAL LENGTH=10.0, REAL WIDTH=20.0, REAL HIGHT=30.0)
...
N100 RET
```

Different call variants:

Program code

```
PROC MAIN_PROG
 REAL PAR_1 = 100
 REAL PAR_2 = 200
 REAL PAR_3 = 300
 ; Call variants
 SUB_PROG
 SUB_PROG(PAR_1, PAR_2, PAR_3)
 SUB_PROG(PAR_1)
 SUB_PROG(PAR_1, , PAR_3)
 SUB_PROG( , , PAR_3)
N100 RET
```

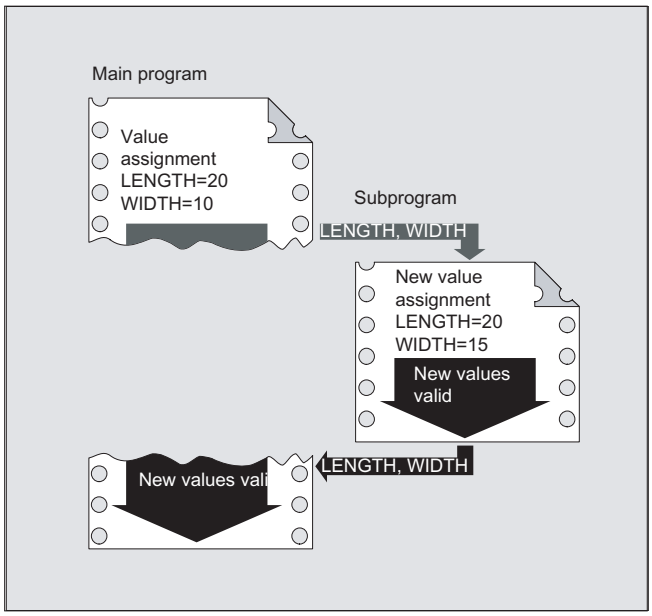
1.24.2.3 Subprogram with call-by-reference parameter transfer (PROC, VAR)

Function

A subprogram with call-by-reference parameter transfer is defined using the PROC keyword followed by the name of the program and a complete list of all the parameters expected by the subprogram, with the VAR keyword, type and name. The definition operation must appear in the first program line.

With call-by-reference parameter transfer, references to arrays can also be transferred.

Call-by-reference parameter transfer affects the calling program. The calling program transfers a reference to the actual parameter to the subprogram, thereby providing the subprogram with direct access to the corresponding variable.



Note

A maximum of 127 parameters can be transferred.

Note

Call-by-reference parameter transfer is then only necessary if the transferred variable was defined in the calling program (LUD). Channel-global or NC-global variables do not have to be transferred, since these cannot be accessed directly from within the subprogram.

Syntax

```
PROC <program name> (VAR <parameter type> <parameter name>, etc.)
PROC <program name> (VAR <array type> <array name>, [<m>,<n>,<o>],
etc.)
```

Meaning

`PROC`:	Definition operation at the beginning of a program
`VAR`:	Keyword for parameter transfer via reference
`<program name>`:	Name of the program
`<parameter type>`:	Data type of the parameter (e.g. REAL, INT, BOOL)
`<parameter name>`:	Name of the parameter
`<array type>`:	Data type of the array elements (e.g. REAL, INT, BOOL)

<array name>:	Name of the array
[<m>,<n>,<o>]:	Array size Currently, up to 3-dimensional arrays are possible: <m>: Array size for 1st dimension <n>: Array size for 2nd dimension <o>: Array size for 3rd dimension

Note

The program name specified after the PROC keyword must match the program name assigned on the user interface.

Note

With arrays of an undefined array length, subprograms can process arrays of variable length as formal parameter. When defining a two-dimensional array as a formal parameter, for example, the length of the 1st dimension is not specified. However, the comma must be written.

Example: PROC <program name> (VAR REAL ARRAY[,5])

Example

Definition of a subprogram with 2 parameters as reference to REAL type:

```
Program code                                          Comment
PROC SUB_PROG(VAR REAL LENGTH, VAR REAL WIDTH)        ; Parameter 1: Reference to type: REAL,
                                                        name: LENGTH
                                                      Parameter 2: Reference to type: REAL,
                                                        name: WIDTH
...
N100 RET
```

1.24.2.4 Save modal G functions (SAVE)

Function

The SAVE attribute means that before the subprogram call, active modal G functions are saved and are re-activated after the end of the subprogram.

NOTICE
Interrupt continuous-path mode
If, for active continuous-path mode, a sub-program is called with the SAVE attribute, the continuous-path mode is interrupted at the end of the sub-program (return jump).

Syntax

```
PROC <subprogram name> SAVE
```

Meaning

SAVE: Saves the modal G functions before the subprogram call and restores after the end of the subprogram.

Example

The modal G function G91 is effective in the CONTOUR subprogram (incremental dimension). The modal G function G90 is effective in the main program (absolute dimension). G90 is again effective in the main program after the end of the subprogram due to the subprogram definition with SAVE.

Subprogram definition:

Program code	Comment
PROC CONTOUR (REAL VALUE1) SAVE	; Subprogram definition with the SAVE parameter
N10 G91 ...	; Modal G function G91: Incremental dimension
N100 M17	; End of subprogram

Main program:

Program code	Comment
N10 G0 X... Y... G90	; Modal G function G90: Absolute dimensions
N20 ...	
...	
N50 CONTOUR (12.4)	; Subprogram call
N60 X... Y...	; Modal G function G90 reactivated using SAVE

Supplementary conditions

Frames

The behavior of frames regarding subprograms with the SAVE attribute depends on the frame time and can be set using machine data.

References

Function Manual, Basic Functions; Axes, Coordinate Systems, Frames (K2),
Section: "Subprogram return with SAVE"

1.24.2.5 Suppress single block execution (SBLOF, SBLON)

Function

Single block suppression for the complete program

Programs designated with SBLOF are completely executed just like a block when single block execution is active, i.e. single block execution is suppressed for the complete program.

SBLOF is in the PROC line and is valid up to the end of the subprogram or until it is interrupted. At the return command, the decision is made whether to stop at the end of the subprogram:

Return jump with M17:	Stop at the end of the subprogram
Return jump with RET:	No stop at end of subprogram

Single block suppression within the program

SBLOF alone must remain in the block. Single block is deactivated after this block until:

- To the next SBLON

  or

- To the end of the active subprogram level

Syntax

Single block suppression for the complete program:

```
PROC ... SBLOF
```

Single block suppression within the program:

```
SBLOF
...
SBLON
```

Meaning

PROC:	First operation in a program
SBLOF:	Command to deactivate single block execution SBLOF can be written in a PROC block or alone in the block.
SBLON:	Command to activate single block execution SBLON must be in a separate block.

Supplementary conditions

- **Single block suppression and block display**

  The current block display can be suppressed in cycles/subprograms using DISPLOF. IfDISPLOF is programmed together withSBLOF, then the cycle/subprogram call continues to be displayed on single-block stops within the cycle/subprogram.

- **Single block suppression in the system ASUB or user ASUB**

  If the single block stop in the system or user ASUB is suppressed using the settings in machine data MD10702 $MN_IGNORE_SINGLEBLOCK_MASK (bit0 = 1 or bit1 = 1), then the single block stop can be re-activated by programming SBLON in the ASUB.

  If the single block stop in the user ASUB is suppressed using the setting in machine data MD20117 $MC_IGNORE_SINGLEBLOCK_ASUP then the single block stop **cannot** be reactivated by programming SBLON in the ASUB.

- **Special features of single block suppression for various single block execution types**

  When single block execution SBL2 is active (stop after each part program block) there is **no** execution stop in the SBLON block if bit 12 is set to "1" in the MD10702 $MN_IGNORE_SINGLEBLOCK_MASK (prevent single block stop).

  When single block execution SBL3 is active (stop after every part program block - also in the cycle), the SBLOF command is suppressed.

Examples

Example 1: Single block suppression within a program

```
Program code                    Comment
N10 G1 X100 F1000
N20 SBLOF                       ; Deactivate single block
N30 Y20
N40 M100
N50 R10=90
N60 SBLON                       ; Reactivate single block
N70 M110
N80 ...
```

The area between N20 and N60 is executed as one step in single-block mode.

Example 2: A cycle is to act like a command for a user

Main program:

```
Program code
N10 G1 X10 G90 F200
N20 X-4 Y6
N30 CYCLE1
N40 G1 X0
N50 M30
```

Cycle CYCLE1:

```
Program code                                Comment
N100 PROC CYCLE1 DISPLOF SBLOF              ; Suppress single block
N110 R10=3*SIN(R20)+5
N120 IF (R11 <= 0)
N130 SETAL(61000)
N140 ENDIF
N150 G1 G91 Z=R10 F=R11
N160 M17
```

CYCLE1 is processed for active single block execution, i.e., the Start key must be pressed once to process CYCLE1.

Example 3:

An ASUB, which is started by the PLC in order to activate a modified zero offset and tool offsets, is to be executed invisibly.

```
Program code
N100 PROC ZO SBLOF DISPLOF
N110 CASE $P_UIFRNUM OF     0 GOTOF _G500
                            1 GOTOF _G54
                            2 GOTOF _G55
                            3 GOTOF _G56
                            4 GOTOF _G57
                            DEFAULT GOTOF END
N120 _G54: G54 D=$P_TOOL T=$P_TOOLNO
N130 RET
N140 _G54: G55 D=$P_TOOL T=$P_TOOLNO
N150 RET
N160 _G56: G56 D=$P_TOOL T=$P_TOOLNO
N170 RET
N180 _G57: G57 D=$P_TOOL T=$P_TOOLNO
N190 RET
N200 END: D=$P_TOOL T=$P_TOOLNO
N210 RET
```

Example 4: Is not stopped with MD10702 Bit 12 = 1

Initial situation:

- Single block execution is active.
- MD10702 $MN_IGNORE_SINGLEBLOCK_MASK Bit12 = 1

Main program:

```
Program code                Comment
N10 G0 X0                   ; Stop in this part program line.
N20 X10                     ; Stop in this part program line.
N30 CYCLE                   ; Traversing block generated by the cycle.
N50 G90 X20                 ; Stop in this part program line.
M30
```

Cycle CYCLE:

```
Program code                Comment
PROC CYCLE SBLOF            ; Suppress single block stop:
N100 R0 = 1
N110 SBLON                  ; Execution is not stopped in the part program line due
                              to the fact that MD10702 bit12=1.
N120 X1                     ; Execution is stopped in this part program line.
N140 SBLOF
N150 R0 = 2
RET
```

Example 5: Single block suppression for program nesting

Initial situation:

Single block execution is active.

Program nesting:

```
Program code                                Comment
N10 X0 F1000                                ; Execution is stopped in this block.
N20 UP1(0)
      PROC UP1(INT _NR) SBLOF               ; Suppress single block stop.
      N100 X10
      N110 UP2(0)
            PROC UP2(INT _NR)
            N200 X20
            N210 SBLON                      ; Activate single block stop.
            N220 X22                        ; Execution is stopped in this block.
```

```
Program code                                    Comment
            N230 UP3(0)
                  PROC UP3(INT _NR)
                  N300 SBLOF                    ; Suppress single block stop.
                  N305 X30
                  N310 SBLON                    ; Activate single block stop.
                  N320 X32                      ; Execution is stopped in this block.
                  N330 SBLOF                    ; Suppress single block stop.
                  N340 X34
                  N350 M17                      ; SBLOF is active.
            N240 X24                            ; Execution is stopped in this block.
                                                  SBLON is active.
            N250 M17                            ; Execution is stopped in this block.
                                                  SBLON is active.
      N120 X12
      N130 M17                                  ; Execution is stopped in this
                                                  return jump block. SBLOF of the PROC
                                                  instruction is active.
N30 X0                                          ; Execution is stopped in this block.
N40 M30                                         ; Execution is stopped in this block.
```

Further Information

Single block disable for unsynchronized subprograms

In order to execute an ASUB in one step, a PROC instruction must be programmed in the ASUB with SBLOF. This also applies to the function "Editable system ASUB" (MD11610 $MN_ASUP_EDITABLE).

Example of an editable system ASUB:

```
Program code                                    Comments
N10 PROC ASUB1 SBLOF DISPLOF
N20 IF $AC_ASUP==’H200’
N30 RET                                         ; No REPOS for mode change.
N40 ELSE
N50 REPOSA                                      ; REPOS in all other cases.
N60 ENDIF
```

Program control in single block mode

With the single block execution function, the user can execute a part program block-by-block. The following setting types exist:

- SBL1: IPO single block with stop after each machine function block.
- SBL2: Single block with stop after each block.
- SBL3: Stop in the cycle (the SBLOF command is suppressed by selecting SBL3).

Single block suppression for program nesting

If SBLOF was programmed in the PROC instruction in a subprogram, then execution is stopped at the subprogram return jump with M17. That prevents the next block in the calling program from already running. If SBLOF, without SBLOF is programmed in the PROC instruction in a subprogram, single block suppression is activated, execution is only stopped after the next machine function block of the calling program. If that is not wanted, SBLON must be programmed in the subprogram before the return (M17). Execution does not stop for a return jump to a higher-level program with RET.

1.24.2.6 Suppress current block display (DISPLOF, DISPLON, ACTBLOCNO)

Function

The current program block is displayed as standard in the block display. The display of the current block can be suppressed in cycles and subprograms using the DISPLOF command. Instead of the current block, the call of the cycle or the subprogram is displayed. The DISPLON command can be used to revoke suppression of the block display.

DISPLOF and DISPLON are programmed in the program line with the PROC operation and are effective for the entire subprogram and implicitly for all subprograms called from it which do not contain a DISPLON or DISPLOF command. This is true of all ASUBs.

Syntax

```
PROC … DISPLOF
PROC … DISPLOF ACTBLOCNO
PROC … DISPLON
```

Meaning

DISPLOF: Command to suppress the current block display.

Location: At the end of the program line with the PROC operation

Effective: Up to the return jump from the subprogram or end of program.

Note:
If further subprograms are called from the subprogram using the DISPLOF command, then the current block display is also suppressed in these subprograms unless DISPLON is explicitly programmed in them.

DISPLON: Command for revoking suppression of the display of the current block

Location: At the end of the program line with the PROC operation

Effective: Up to the return jump from the subprogram or end of program.

Note:
If further subprograms are called from the subprogram using the DISPLON command, then the current block will also be displayed in these subprograms unless DISPLOF is explicitly programmed in them.

ACTBLOCNO: DISPLOF together with the ACTBLOCNO attribute means that in the case of an alarm, the number of the actual block is output in which the alarm occurred. The also applies if only DISPLOF is programmed in a lower program level.

On the other hand, for DISPLOF without ACTBLOCNO, the block number of the cycle or subprogram call from the last program level not designated with DISPLOF is displayed.

Examples

Example 1: Suppress current block display in the cycle

```
Program code                                                    Comment
PROC CYCLE (AXIS TOMOV, REAL POSITION) SAVE DISPLOF             ; Suppress current block display
                                                                  Instead, the cycle call should be
                                                                  displayed, e.g.: CYCLE(X,100.0)
DEF REAL DIFF                                                   ; Cycle contents
G01 ...
...
RET                                                             ; Subprogram return jump. The block
                                                                  following the cycle call is
                                                                  displayed in the block display.
```

Example 2: Block display for alarm output

Subprogram SUBPROG1 (with ACTBLOCNO):

```
Program code                                Comment
PROC SUBPROG1 DISPLOF ACTBLOCNO
N8000 R10 = R33 + R44
...
N9040 R10 = 66 X100                         ; Trigger alarm 12080
...
N10000 M17
```

Subprogram SUBPROG2 (without ACTBLOCNO):

```
Program code                        Comment
PROC SUBPROG2 DISPLOF
N5000 R10 = R33 + R44
...
N6040 R10 = 66 X100                 ; Trigger alarm 12080
...
N7000 M17
```

Main program:

Program code	Comment
N1000 G0 X0 Y0 Z0	
N1010 ...	
...	
N2050 SUBPROG1	; Alarm output = "12080 channel K1 block N9040 syntax error for text R10="
N2060 ...	
N2350 SUBPROG2	; Alarm output = "12080 channel K1 block N2350 syntax error for text R10="
...	
N3000 M30	

Example 3: Revoke suppression of the current block display

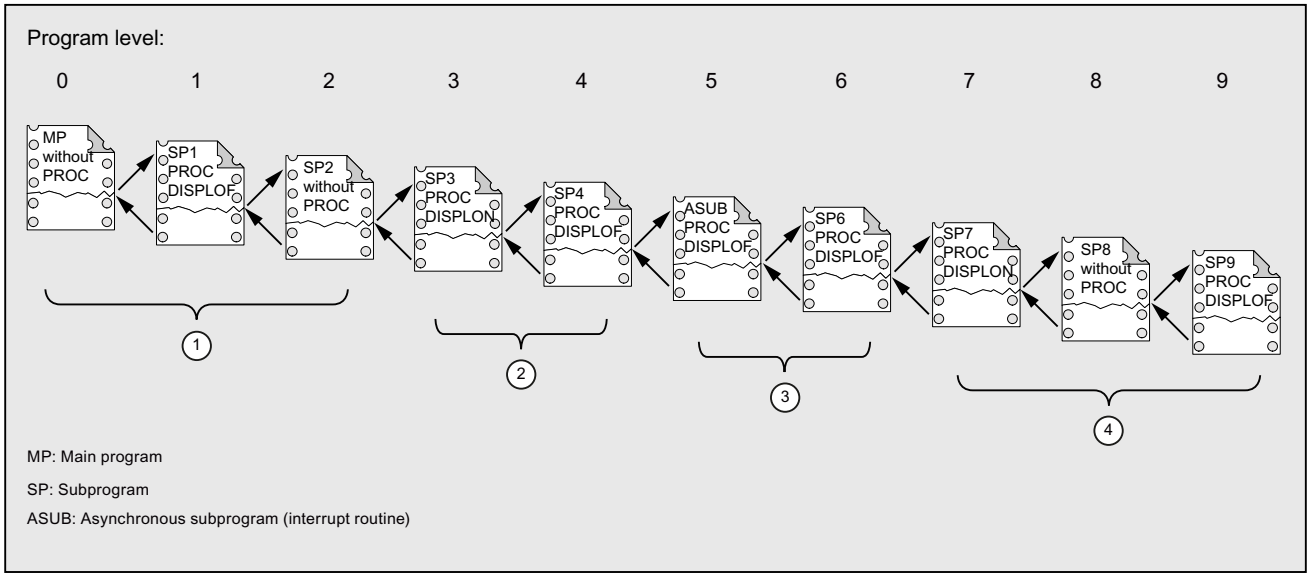
Subprogram SUB1 with suppression:

Program code	Comment
PROC SUB1 DISPLOF	; Suppress current block display in SUB1 subprogram. Instead, the block is to be displayed with the SUB1 call.
...	
N300 SUB2	; Call subprogram SUB2.
...	
N500 M17	

Subprogram SUB2 without suppression:

Program code	Comment
PROC SUB2 DISPLON	; Revoke suppression of the current block display in subprogram SUB2.
...	
N200 M17	; Return to subprogram SUB1. Suppression of the current block display is restored in SUB1.

Example 4: Display response in the case of different DISPLON/DISPLOF combinations



① The part program lines from program level 0 are displayed in the current block display.
② The part program lines from program level 3 are displayed in the current block display.
③ The part program lines from program level 3 are displayed in the current block display.
④ The part program lines from program level 7/8 are displayed in the current block display.

1.24.2.7 Identifying subprograms with preparation (PREPRO)

Function

All files can be identified with the `PREPRO` keyword at the end of the `PROC` operation line during power up.

Note

This type of program preparation depends on the relevant set machine data. Please follow the manufacturer's instructions.

References:
Function Manual, Special Functions, Preprocessing (V2)

Syntax

```
PROC … PREPRO
```

Meaning

`PREPRO`: Keyword for identifying all files (of the NC programs stored in the cycle directories) prepared during power up

Read subprogram with preparation and subprogram call

The cycle directories are processed in the same order both for subprograms preprocessed with parameters during power up and during subprogram call.

1. _N_CUS_DIR user cycles
2. _N_CMA_DIR manufacturer cycles
3. _N_CST_DIR standard cycles

In the case of NC programs sharing the same name but having different characteristics, the first PROC operation found is activated and the other PROC operation is overlooked without an alarm message.

1.24.2.8 Subprogram return M17

Function

The return command M17 (or the part program end command M30) appears at the end of a subprogram. It prompts the return to the calling program at the part program block following the subprogram call.

Note

M17 and M30 are treated as equivalents in the NC language.

Syntax

```
PROC <program name>
...
M17/M30
```

Supplementary conditions

Effect of the subprogram return on continuous-path mode

If M17 (or M30) appears on its own in the part program block, active continuous-path mode in the channel will be interrupted.

To avoid continuous-path mode being interrupted, M17 (or M30) has to be included in the last traversing block. Furthermore, the following machine data must be set to "0":

MD20800 $MC_SPF_END_TO_VDI = 0 (no M30/M17 output to the NC/PLC interface)

Example

1. Subprogram with M17 in a separate block

```
Program code                          Comment
N10 G64 F2000 G91 X10 Y10
N20 X10 Z10
N30 M17                               ; Return jump with interruption of continuous-path
                                        mode.
```

2. Subprogram with M17 in the last traversing block

```
Program code                          Comment
N10 G64 F2000 G91 X10 Y10
N20 X10 Z10 M17                       ; Return jump without interruption of continuous-
                                        path mode.
```

1.24.2.9 RET subprogram return

Function

The RET command can also be used in the subprogram as a substitute for the M17 return jump command. RET must be programmed in a separate part program block. Like M17, RET prompts the return to the calling program at the part program block following the subprogram call.

Note

Parameters can be programmed to change the return jump behavior of RET (see "Parameterizable subprogram return jump (RET ...) (Page 178)").

Application

The RET operation should then be used if a G64 continuous-path mode (G641 to G645) is not to be interrupted by the return jump.

Requirement

The RET command can only be used in subprograms, which were not defined with the SAVE attribute.

Syntax

```
PROC <program name>
...
RET
```

Example

Main program:

Program code	Comment
PROC MAIN_PROGRAM	; Beginning of the program
...	
N50 SUB_PROG	; Subprogram call: SUB_PROG
N60 ...	
...	
N100 M30	; End of program

Subprogram:

Program code	Comment
PROC SUB_PROG	
...	
N100 RET	; Prompts return jump to block N60 in the main program.

1.24.2.10 Parameterizable subprogram return jump (RET ...)

Function

Usually, an RET or M17 end of subprogram returns to the program from which the subprogram was called and processing continues with the program line following the subprogram call.

However, there are also applications where the program should be resumed at another position, e.g.:

- Resuming program execution after calling the stock removal cycles in the ISO dialect mode (after describing the contour).
- Return to main program from any subprogram level (even after ASUB) for error handling.
- Return jump through several program levels for special applications in compile cycles and in the ISO dialect mode.

In cases such as these, the RET command is programmed together with "return jump parameters".

Syntax

```
RET("<target block>")
RET("<target block>",<block after target block>)
RET("<target block>",<block after target block> <number of return
jump levels>)
RET("<target block>", ,<number of return jump levels>)
RET("<target block>",<block after target block>,<number of return
jump levels>,
<return jump to the beginning of the program>)
RET( , ,<number of return jump levels>,<return jump to the beginning
of the program>)
```

Meaning

`RET`: Subprogram end (use instead of `M17`)

`<target block>`: Return jump parameter 1

Declares as jump destination the block where program execution should be resumed.

If the return jump parameter 3 is not programmed, then the jump destination is in the program from which the current subprogram was called.

Possible data include:

"<block number>"	Number of the target block
"<jump marker>"	Jump marker that must be set in the target block.
"<character string>"	Character string that must be known in the program (e.g. program or variable name). The following rules apply when programming the character string: • **Blank at the end** (contrary to the jump marker, that is designated using ":" at the end). • **Before the character string** only one block number and/or a jump marker may be set, **no program commands**.

`<block after target block>`: Return jump parameter 2

Refers to the return jump parameter 1.

Type: INT

Value:		
	0	Return jump is made to the block that was specified using return jump parameter 1.
	> 0	Return jump is made to the block that follows the block specified with return jump parameter 1.

`<number of return jump levels>`:

Return jump parameter 3

Specifies the number of levels that must be jumped back in order to reach the program level in which program execution should be continued.

Type: INT

Value:
- 1 The program is resumed at the "current program level - 1" (like `RET` without parameter).
- 2 The program is resumed at the "current program level - 2", i.e. one level is skipped.
- 3 The program is resumed at the "current program level - 3", i.e. two levels are skipped.
- ...

Value range: 1 ... 15

`<return jump to the beginning of the program>`:

Return jump parameter 4

Type: BOOL

Value:
- 1 If the return jump is made into the main program and an **ISO dialect mode** is active there, then the program branches to the beginning of the program.

Note

For a subprogram return jump with a character string to specify the target block search, initially, a search is always made for a jump marker in the calling program.

If a jump destination is to be uniquely defined using a character string, it is not permissible that the character string matches the name of a jump marker, as otherwise the subprogram return jump would always be made to the jump marker and not to the character string (refer to example 2).

Supplementary conditions

When making a return jump through several program levels, the SAVE statements of the individual program levels are evaluated.

If, for a return jump over several program levels, a modal subprogram is active and if in one of the skipped programs the deselection command MCALL is programmed for the modal subprogram, then the modal subprogram remains active.

NOTICE
Programming error
The programmer must carefully ensure that for a return jump over several program levels, the program continues with the correct modal settings. This can be achieved, e.g. by programming an appropriate main block.

Examples

Example 1: Resuming in the main program after ASUB execution

```
Programming                                Comment
N10010 CALL "UP1"                          ;Program level 0 (main program)
  N11000 PROC UP1                          ; Program level 1
  N11010 CALL "UP2"
  N12000 PROC UP2                          ; Program level 2
  ...
  N19000 PROC ASUB                         ; Program level 3 (ASUB execution)
  ...
  N19100 RET("N10900", ,$P_STACK)          ; Subprogram return
N10900                                     ; Resumption in main program.
N10910 MCALL                               ; Deactivate modal subprogram.
N10920 G0 G60 G40 M5                       ; Correct additional modal settings.
```

Example 2: Character string (string>) to specify the target block search

Main program:

```
Program code                               Comment
PROC MAIN_PROGRAM
N1000 DEF INT iVar1=1, iVar2=4
N1010 ...
N1200 subProg1                             ; Calls subprogram "subProg1"
N1210 M2 S1000 X10 F1000
N1220 ......
N1400 subProg2                             ; Calls subprogram "subProg2"
N1410 M3 S500 Y20
```

```
Program code                                Comment
N1420 ..
N1500 lab1: iVar1=R10*44
N1510 F500 X5
N1520 ...
N1550 subprog1: G1 X30                      ; "subProg1" is defined here as jump marker.
N1560 ...
N1600 subProg3                              ; Calls subprogram "subProg3"
N1610 ...
N1900 M30
```

Subprogram subProg1:

```
Program code                        Comment
PROC subProg1
N2000 R10=R20+100
N2010 ...
N2200 RET("subProg2")               ; Return jump into the main program at block N1400
```

Subprogram subProg2:

```
Program code                        Comment
PROC subProg2
N2000 R10=R20+100
N2010 ...
N2200 RET("iVar1")                  ; Return jump into the main program at block N1500
```

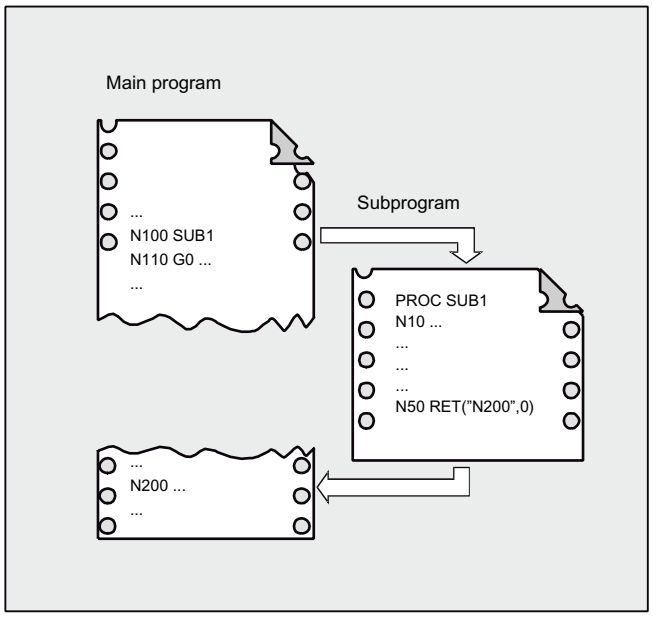
Subprogram subProg3:

```
Program code                        Comment
PROC subProg3
N2000 R10=R20+100
N2010 ...
N2200 RET("subProg1")               ; Return jump into the main program at block N1550
```

Further information

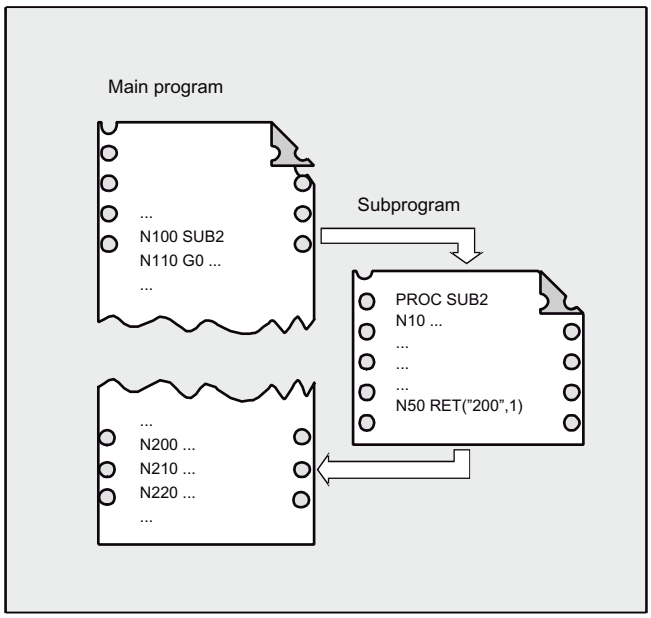
The different effects of return jump parameters 1 to 3 are explained in the following graphics.

1st return jump parameter 1 = "N200", return jump parameter 2 = 0



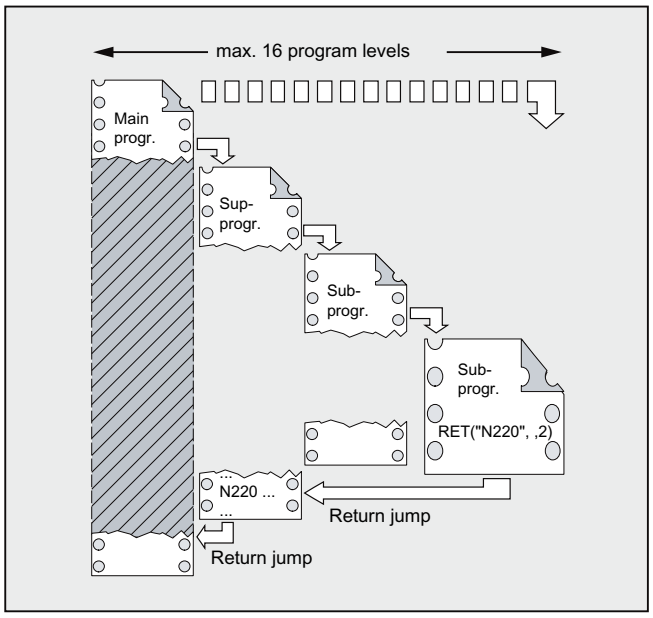
After the `RET` command, program execution is continued with block `N200` in the main program.

2nd return jump parameter 1 = "N200", return jump parameter 2 = 1



After the `RET` command, program execution is continued with the block (`N210`) that follows block `N200` in the main program.

3rd return jump parameter 1 = "N220", return jump parameter 3 = 2



After the `RET` command, two program levels are jumped through and program execution is continued with block `N220`.

1.24.3 Subprogram call

1.24.3.1 Subprogram call without parameter transfer

Function

A subprogram is called either with address L and subprogram number or by specifying the program name.

A main program can also be called as a subprogram. The end of program `M2` or `M30` set in the main program is evaluated as `M17` in this case (end of program with return to the calling program).

Note

Accordingly, a subprogram can also be started as a main program.

Search strategy of the control:

Are there any *_MPF?

Are there any *_SPF?

This means: if the name of the subprogram to be called is identical to the name of the main program, the main program that issued the call is called again. This is generally an undesirable effect and must be avoided by assigning unique names to subprograms and main programs.

Note

Subprograms not requiring parameter transfer can also be called from an initialization file.

Syntax

```
L<number>/<program name>
```

Note

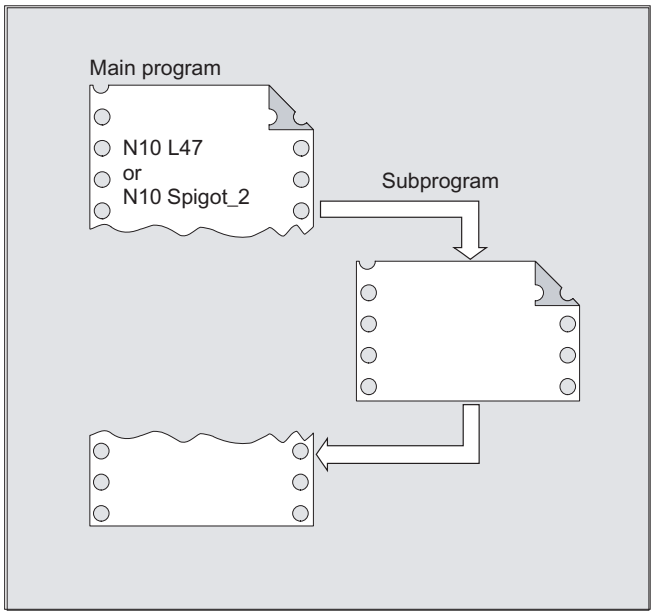
The subprogram call must always be programmed in a separate NC block.

Meaning

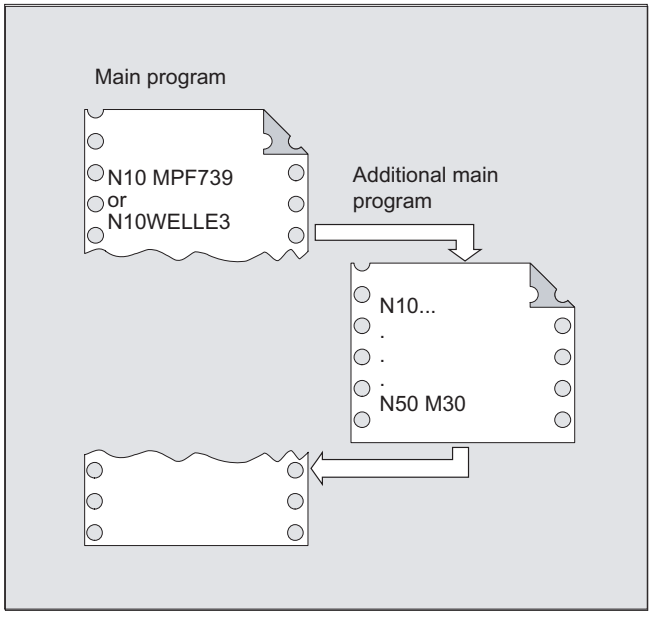
`L`:	Address for the subprogram call	
`<number>`:	Name of the subprogram	
	Type:	INT
	Value:	Maximum 7 decimal places
		Notice: Leading zeros are significant in names (⇒ L123, L0123 and L00123 are three different subprograms).
`<program name>`:	Name of the subprogram (or main program)	

Examples

Example 1: Subprogram call without parameter transfer



Example 2: Calling a main program as a subprogram



1.24.3.2 Subprogram call with parameter transfer (EXTERN)

Function

For a subprogram call with parameter transfer, variables or values can be transferred directly (but not VAR parameters).

Subprograms with parameter transfer must be declared with EXTERNAL in the main program before they are called in the main program (e.g. at the beginning of the program). The name of the subprogram and the variable types are thereby specified in the sequence in which they are transferred.

NOTICE
Risk of confusion Both the variable types and the sequence of the transfer must match the definitions declared under PROC in the subprogram. The parameter names can be different in the main program and the subprogram.

Syntax

```
EXTERNAL <program name>(<type_Par1>,<type_Par2>,<type_Par3>)
...
<program name>(<value_Par1>,<value_Par2>,<value_Par3>)
```

Note

The subprogram call must always be programmed in a separate NC block.

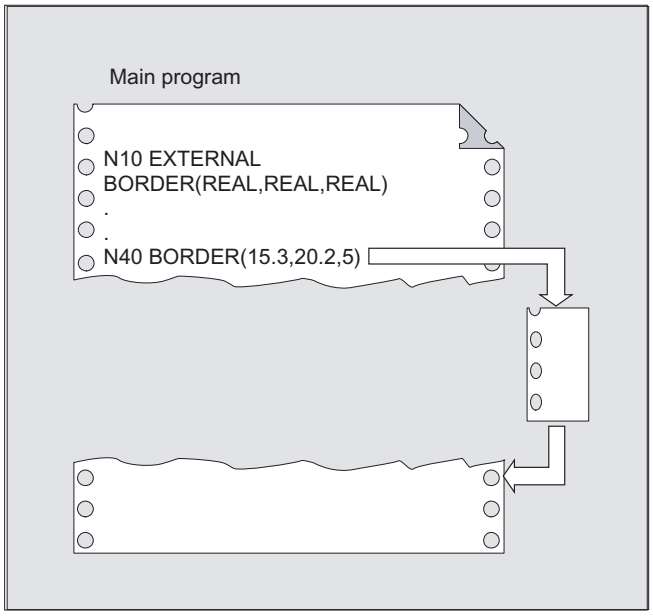
Meaning

<program name>:	Name of subprogram
EXTERNAL:	Keyword to declare a subprogram with parameter transfer. **Note:** You only have to specify EXTERNAL if the subprogram is in the workpiece or in the global subprogram directory. Cycles do not have to be declared as EXTERNAL.
<type_par1>,<type_par2>,<type_par3>:	Variable types of the parameters to be transferred in the sequence of the transfer
<value_par1>,<value_par2>,<value_par3>:	Variable values for the parameters to be transferred

Examples

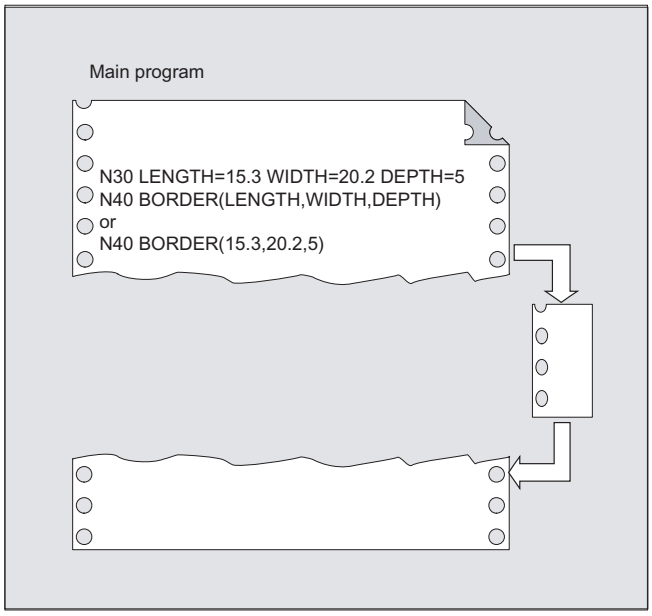
Example 1: Subprogram call preceded by declaration

Program code	Comment
N10 EXTERNAL BORDERS(REAL,REAL,REAL)	; Specify the subprogram.
...	
N40 BORDER(15.3,20.2,5)	; Call the subprogram with parameter transfer.



Example 2: Subprogram call without declaration

Program code	Comment
N10 DEF REAL LENGTH, WIDTH, DEPTH	
N20 …	
N30 LENGTH=15.3 WIDTH=20.2 DEPTH=5	
N40 BORDER(LENGTH,WIDTH,DEPTH)	; or: N40 BORDER(15.3,20.2,5)



1.24.3.3 Number of program repetitions (P)

Function

If a subprogram is to be executed several times in succession, the desired number of program repetitions can be entered at address `P` in the block with the subprogram call.

⚠ CAUTION

Subprogram call with program repetition and parameter transfer

Parameters are transferred only when the program is called, i.e., on the first run. The parameters remain unchanged for the remaining repetitions. If you want to change the parameters during program repetitions, you must make the appropriate provision in the subprogram.

Syntax

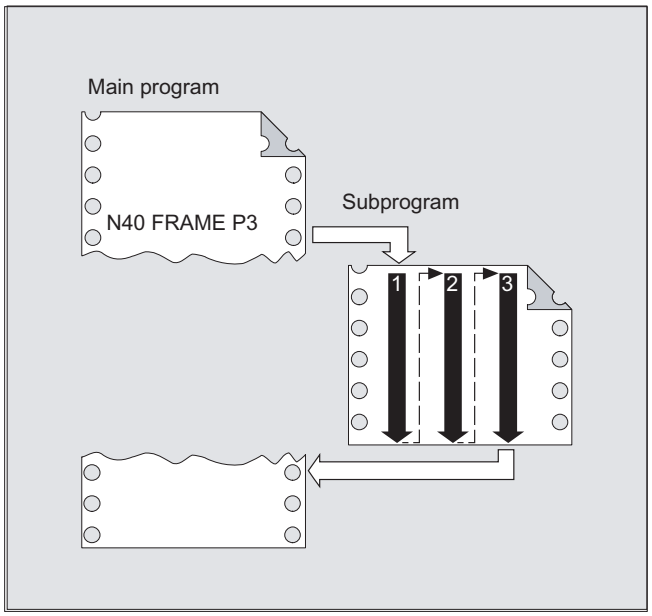
```
<program name> P<value>
```

Meaning

`<program name>`:	Subprogram call	
`P`:	Address to program program repetitions	
`<value>`:	Number of program repetitions	
	Type:	INT
	Range of values:	1 … 9999 (unsigned)

Example

Program code	**Comment**
...	
N40 FRAME P3	; The BORDER subprogram is to be executed three times one after the other.
...	



1.24.3.4 Modal subprogram call (MCALL)

Function

For a modal subprogram call with MCALL, the subprogram is automatically called and executed after each block with path motion. This allows subprogram calls to be automated, which are to be executed at different workpiece positions (for example to create drilling patterns).

MCALL is used to deactivate the function without a subprogram call or by programming a new modal subprogram call for a new subprogram.

Note

Only one MCALL call can be effective at one time in a program run. Parameters are only transferred once for an MCALL call.

In the following situations the modal subprogram is also called without motion programming:

- Programming addresses S and F if G0 or G1 is active.
- If G0/G1 were programmed alone in the block or with additional G codes.

Note

No modal subprogram calls are made in ASUBs that would interrupted by the processing of a part program (see "Interrupt routine (ASUB) (Page 121)").

However, ASUBs that were started from the reset state behave like normal part programs with regard to the modal subprogram calls.

Syntax

```
MCALL <program name>
```

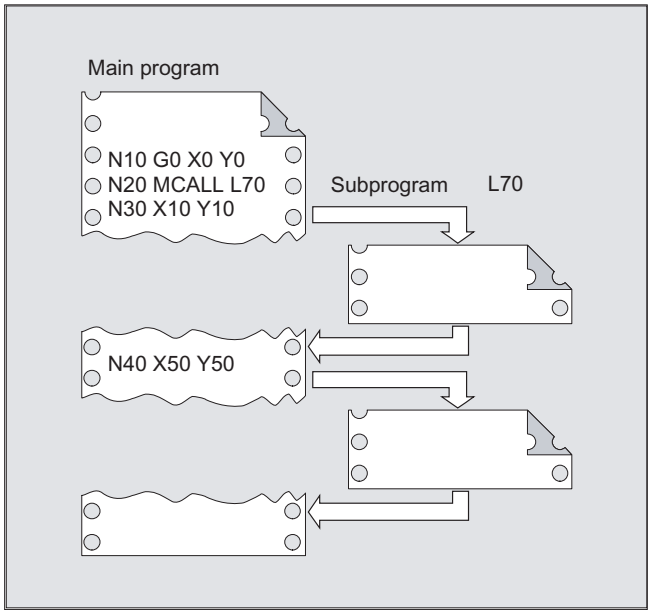
Meaning

MCALL:	Command for the modal subprogram call
<program name>:	Name of subprogram

Examples

Example 1:

Program code	Comment
N10 G0 X0 Y0	
N20 MCALL L70	; Modal subprogram call.
N30 X10 Y10	; The programmed position is approached and then subprogram L70 is executed.
N40 X50 Y50	; The programmed position is approached and then subprogram L70 is executed.



Example 2:

Program code
N10 G0 X0 Y0
N20 MCALL L70
N30 L80

In this example, the following NC blocks with programmed path axes are in subprogram L80. L70 is called by L80.

1.24.3.5 Indirect subprogram call (CALL)

Function

Depending on the prevailing conditions at a particular point in the program, different subprograms can be called. The name of the subprogram is stored in a variable of the STRING type. The subprogram call is realized with `CALL` and the variable name.

Note

The indirect subprogram call is only possible for subprograms without parameter transfer. For a direct subprogram call, save the name in a STRING constant.

Syntax

```
CALL <program name>
```

Meaning

`CALL`:	Command for the indirect subprogram call.
`<program name>`:	Name of the subprogram (variable or constant) Type: STRING

Example

Direct call with STRING constant:

```
Program code                                                    Comment
…
CALL "/_N_WKS_DIR/_N_SUBPROG_WPD/_N_PART1_SPF"                   ; Direct call to subprogram
                                                                PART1 with CALL.
…
```

Indirect call via variable:

```
Program code                                                    Comment
…
DEF STRING[100] PROGNAME                                        : Define variable.
PROGNAME="/_N_WKS_DIR/_N_SUBPROG_WPD/_N_PART1_SPF"              ; Assign subprogram PART1 to
                                                                the PROGNAME variable.
CALL PROGNAME                                                   ; Indirect call to subprogram
                                                                PART1 via CALL and the
                                                                PROGNAME variable.
…
```

1.24.3.6 Indirect subprogram call with specification of the calling program part (CALL BLOCK ... TO ...)

Function

`CALL` and the keyword combination `BLOCK ... TO` is used to call a subprogram indirectly and execute the program part designated by the start and end labels.

Syntax

```
CALL <program name> BLOCK <start label> TO <end label>
CALL BLOCK <start label> TO <end label>
```

Meaning

`CALL`:	Command for the indirect subprogram call.
`<program name>`:	Name of the subprogram (variable or constant) that contains the program part to be executed (**specification optional**). Type: STRING **Note:** If a `<program name>` has not been programmed, the program part designated by `<start label>` and `<end label>` is searched for in the current program and executed.
`BLOCK ... TO ...` :	Keyword combination for indirect program part execution
`<start label>`:	Variable that refers to the start of the program part to be executed. Type: STRING
`<end label>`:	Variable that refers to the end of the program part to be executed. Type: STRING

Example

Main program:

```
Program code                                          Comment
...
DEF STRING[20] STARTLABEL, ENDLABEL                   ; Variable definition for the
                                                        start and end labels.
STARTLABEL="LABEL_1"
ENDLABEL="LABEL_2"
...
CALL "CONTUR_1" BLOCK STARTLABEL TO ENDLABEL          ; Indirect subprogram call and
                                                        identifier associated with
                                                        the calling program part.
...
```

Subprogram:

```
Program code                Comment
PROC CONTUR_1 ...
LABEL_1                     ; Start label: Start of program part execution.
N1000 G1 ...
...
LABEL_2                     ; End label: End of program part execution.
...
```

1.24.3.7 Indirect call of a program programmed in ISO language (ISOCALL)

Function

A program programmed in an ISO language can be called using the indirect program call ISOCALL. The ISO mode set in the machine data is then activated. The original execution mode becomes effective again at the end of the program. If no ISO mode is set in the machine data, the subprogram is called in Siemens mode.

For further information about the ISO mode, see
References:
ISO Dialects Functional Description

Syntax

```
ISOCALL <program_name>
```

Meaning

ISOCALL:	Keyword for an indirect subprogram call with which the ISO mode set in the machine data is activated.
<program name>:	Name of the program programmed in an ISO language (variable or constant, type STRING)

Example: Calling a contour with cycle programming from ISO mode

```
Program code                                Comment
0122_SPF                                    ; Contour description in the ISO
                                              mode
N1010 G1 X10 Z20
N1020 X30 R5
N1030 Z50 C10
N1040 X50
N1050 M99
```

Program code	Comment
N0010 DEF STRING[5] PROGNAME = "0122"	; Siemens part program (cycle)
...	
N2000 R11 = $AA_IW[X]	
N2010 ISOCALL PROGNAME	
N2020 R10 = R10+1	; Execute program 0122.spf in the ISO mode
...	
N2400 M30	

1.24.3.8 Call subprogram with path specification and parameters (PCALL)

Function

With PCALL you can call subprograms with the absolute path and parameter transfer.

Syntax

```
PCALL <path/program name>(<parameter 1>,…,<parameter n>)
```

Meaning

PCALL:	Keyword for subprogram call with absolute path name
<path/program name>:	Absolute path name beginning with "/", including subprogram names If no absolute path name is specified, PCALL behaves like a standard subprogram call with a program identifier. The program identifier is written without the leading _N_ and without an extension. If the program name is to be programmed with leading character and extension, then it must be explicitly declared with leading character and extension using the EXTERN command.
<parameter 1>, etc.:	Actual parameters in accordance with the PROC operation of the subprogram.

Example

Program code
PCALL/_N_WKS_DIR/_N_WELLE_WPD/WELLE(parameter1,parameter2,…)

1.24.3.9 Extend search path for subprogram calls (CALLPATH)

Function

The search path for subprogram calls can be extended using the CALLPATH command.

This means that also subprograms can be called from a non-selected workpiece directory without having to specify the complete, absolute path name of the subprogram.

The search path extension is made before the entry for user cycles (_N_CUS_DIR).

The search path extension is deselected again as a result of the following events:

- CALLPATH with blanks
- CALLPATH without parameter
- End of part program
- Reset

Syntax

```
CALLPATH("<path name>")
```

Meaning

CALLPATH:	Keyword for the programmable search path extension. Is programmed in a separate part program line.
<path name>:	Constant or variable, STRING type. Contains the absolute path name of a directory by which the search path should be extended. The path name starts with "/". The path must be completely specified using prefixes and suffixes. The maximum path length is 128 bytes. If the <path name> contains a blank or if CALLPATH is called without parameter, then the search path statement is reset again.

Example

Program code

```
CALLPATH ("/_N_WKS_DIR/_N_MYWPD_WPD")
```

This means that the following search path is set (position 5. is new):

1. Current directory / subprogram name
2. Current directory / subprogram identifier_SPF
3. Current directory / subprogram identifier_MPF

4. /_N_SPF_DIR/subprogram identifier_SPF
5. **/_N_WKS_DIR/_N_MYWPD_WPD/subprogram identifier_SPF**
6. /N_CUS_DIR/subprogram identifier_SPF
7. /_N_CMA_DIR/subprogram identifier_SPF
8. /_N_CST_DIR/subprogram identifier_SPF

Supplementary conditions

- CALLPATH checks whether the programmed path name actually exists. In the case of an error, part program execution is interrupted with correction block alarm 14009.
- CALLPATH can also be programmed in INI files. It is only effective for the time it takes to process the INI file (WPD-INI file or initialization program for NC active data, e.g. frames in the 1st channel _N_CH1_UFR_INI). The search path is again reset.

1.24.3.10 Execute external subprogram (840D sl) (EXTCALL)

Function

A part program can be loaded from an external memory and executed with the EXTCALL command.

The following are available as external memory:

- Local drive
- Network drive
- USB drive

Note

USB drive

Only the USB interfaces on the operator panel front or the TCU can be used as interface for the processing of an external program on a USB drive.

Note

Do not use a USB-FlashDrive

It is recommended that a USB-FlashDrive is not used for the execution of an external subprogram. A communication interruption to the USB-FlashDrive during the execution of the part program due to contact problems, failure, abort through trigger or unintentional unplugging, results in an immediate stop of the machining. The tool and/or workpiece could be damaged.

Default setting of the external program path

The path for the external program directory can be preset with the setting data:

SD42700 $SC_EXT_PROG_PATH

Together with the program path and identifier specified with the EXTCALL call, this forms the entire path for the subprogram to be called.

Note

Parameter

When calling an external program, none of these parameters can be transferred to it.

Syntax

```
EXTCALL("<path>:<program name>")
```

Meaning

EXTCALL:	Command for calling an external subprogram.	
"<path><program name>":	Constant/variable of type STRING	
	<path>:	Absolute or relative path data (**optional**)
	<program name>:	The program name is specified without prefix "_N_". The file extension ("MPF", "SPF") can be attached to program names using the "_" or "." character (**optional**). Example: "SHAFT" "SHAFT_SPF" "SHAFT.SPF"

Path specification: Short designations

The following short designations can be used to specify the path:

- Local drive: "**LOCAL_DRIVE:**"
- CF card: "**CF_CARD:**"
- USB drive (operator panel front): "**USB:**"

The short designations "CF_CARD:" and "LOCAL_DRIVE:" can be alternatively used.

Example

Execute from local drive

The "MAIN.MPF" main program is stored in NC memory and is selected for execution.

Subprogram "SP_1"

The external subprogram "SP_1.SPF" or "SP_1.MPF" is on the local drive in the directory "/user/sinumerik/data/prog/WKS.DIR/WST1.WPD".

The path for the external program directory is set with:

SD42700 $SC_EXT_PROG_PATH = LOCAL_DRIVE:WKS.DIR/WST1.WPD

Note

Specification of the path for the call of the external subprogram:

- Without using the default setting: `"LOCAL_DRIVE:WKS.DIR/WST1.WPD/SP_1"`
- With use of the default setting: `"SP_1"`

Subprogram "SP_2"

The external subprogram "SP_2.SPF" or "SP_2.MPF" is in the WKS.DIR /WST1.WPD directory of the USB drive. The default path setting to the external program directory is used for the path of subprogram "SP_1" and is also not rewritten in the main program. Therefore, the complete path needs to be specified when subprogram "SP_2" is called.

Main program "MAIN"

Program code

```
N010 PROC MAIN
N020 ...
N030 EXTCALL("SP_1")
N030 EXTCALL("USB:WKS.DIR/WST1.WPD/SP_2")
N050 ...
N060 M30
```

Further information

EXTCALL call with absolute path name

If the subprogram exists under the specified path, it is executed with the `EXTCALL` call. If the subprogram does not exist under the specified path, the program execution is aborted with the `EXTCALL` call.

EXTCALL call with relative path name / without path name

In the event of an `EXTCALL` call with a relative path name or without a path name, the available program memories are searched as follows:

1. If a path name is preset in SD42700 $SC_EXT_PROG_PATH, the data specified in the `EXTCALL` call (program name or with relative path name) is searched for first, starting from this path. The absolute path is obtained from linking the following characters:
   - Default path specification in SD42700 $SC_EXT_PROG_PATH
   - Separator "/"
   - Path specification and subprogram name in the `EXTCALL` command

2. If the subprogram was not found under 1., the directories of the user memory are searched.

The search ends when the subprogram is found for the first time. If the subprogram is not found, the program execution is aborted with the EXTCALL call.

Adjustable reload memory (FIFO buffer)

A reload memory is required for the execution of an external subprogram. The size of the reload memory is preset with 30KB and can only be changed by the machine manufacturer (using MD18360 MM_EXT_PROG_BUFFER_SIZE).

Note

Subprograms with jump commands

For external subprograms that contain jump commands (GOTOF, GOTOB, CASE, FOR, LOOP, WHILE, REPEAT, IF, ELSE, ENDIF etc.) the jump destinations must lie within the post loading memory.

Note

ShopMill/ShopTurn programs

The contour descriptions added at the file end mean the ShopMill and ShopTurn programs must be stored completely in the read-only memory.

A separate reload memory is required for external subprograms executed in parallel.

Reset / end of program / POWER ON

Reset and POWER ON cause external subprogram calls to be interrupted and the associated reload memory to be erased.

A subprogram selected for "Execution from external source" remains selected for "Execution from external source" after a reset / end of program. A POWER ON deletes the selection.

References

Further information on "Execution from external source" can be found in:

Function Manual, Basic Functions, Mode Group, Channel, Program Operation, Reset Behavior (K1)

1.24.3.11 Execute external subprogram (828D) (EXTCALL)

Function

A part program can be loaded from an external memory and executed with the `EXTCALL` command.

The following are available as external memory:

- User CF card
- Network drive
- USB drive

Note

USB drive

As the interface for the execution of an external program located on a USB drive, only the USB interface of the operator panel front (PPU) may be used.

Note

Do not use a USB-FlashDrive

It is recommended that a USB-FlashDrive is not used for the execution of an external subprogram. A communication interruption to the USB FlashDrive during the execution of the subprogram due to contact problems, failure, abort through trigger or unintentional unplugging, results in an immediate stop of the machining. The tool and/or workpiece could be damaged.

Default setting of the external program path

The path for the external program directory can be preset with the setting data:

SD42700 $SC_EXT_PROG_PATH

Together with the program path and identifier specified with the `EXTCALL` call, this forms the entire path for the subprogram to be called.

Note

Parameter

When calling an external program, none of these parameters can be transferred to it.

Syntax

```
EXTCALL("<path>:<program name>")
```

Meaning

EXTCALL:	Command for calling an external subprogram.	
"<path><program name>":	Constant/variable of type STRING	
	<path>:	Absolute or relative path data (**optional**)
	<program name>:	The program name is specified without prefix "_N_". The file extension ("MPF", "SPF") can be attached to program names using the "_" or "." character (**optional**). Example: "SHAFT" "SHAFT_SPF" "SHAFT.SPF"

Path specification: Short designations

The following short designations can be used to specify the path:

- User CF card: "**CF_CARD:**"
- USB drive (operator panel front): "**USB:**"

Example

The "MAIN.MPF" main program is stored in NC memory and is selected for execution.

Subprogram "SP_1"

The external subprogram "SP_1.SPF" or "SP_1.MPF" is on the user CF card in the "/WKS.DIR /WST1.WPD" directory.

The path for the external program directory is set with:

SD42700 $SC_EXT_PROG_PATH = CF_CARD:WKS.DIR/WST1.WPD

Note

Specification of the path for the call of the external subprogram:

- Without using the default setting: "CF_CARD:WKS.DIR/WST1.WPD/SP_1"
- With use of the default setting: "SP_1"

Subprogram "SP_2"

The external subprogram "SP_2.SPF" or "SP_2.MPF" is in the WKS.DIR /WST1.WPD directory of the USB drive. The default path setting to the external program directory is used for the path of subprogram "SP_1" and is also not rewritten in the main program. Therefore, the complete path needs to be specified when subprogram "SP_2" is called.

Main program "MAIN"

```
Program code
N010 PROC MAIN
N020 ...
N030 EXTCALL("SP_1")
N030 EXTCALL("USB:WKS.DIR/WST1.WPD/SP_2")
N050 ...
N060 M30
```

Further information

EXTCALL call with absolute path name

If the subprogram exists under the specified path, it is executed with the EXTCALL call. If the subprogram does not exist under the specified path, the program execution is aborted with the EXTCALL call.

EXTCALL call with relative path name / without path name

In the event of an EXTCALL call with a relative path name or without a path name, the available program memories are searched as follows:

1. If a path name is preset in SD42700 $SC_EXT_PROG_PATH, the data specified in the EXTCALL call (program name or with relative path name) is searched for first, starting from this path. The absolute path is obtained from linking the following characters:
   - Default path specification in SD42700 $SC_EXT_PROG_PATH
   - Separator "/"
   - Path specification and subprogram name in the EXTCALL command
2. If the subprogram was not found under 1., the directories of the user memory are searched.

The search ends when the subprogram is found for the first time. If the subprogram is not found, the program execution is aborted with the EXTCALL call.

Adjustable reload memory (FIFO buffer)

A reload memory is required for the execution of an external subprogram. The size of the reload memory is preset (see MD18360 MM_EXT_PROG_BUFFER_SIZE).

Note

Subprograms with jump commands

For external subprograms that contain jump commands (GOTOF, GOTOB, CASE, FOR, LOOP, WHILE, REPEAT, IF, ELSE, ENDIF etc.) the jump destinations must lie within the post loading memory.

Note

ShopMill/ShopTurn programs

The contour descriptions added at the file end mean the ShopMill and ShopTurn programs must be stored completely in the read-only memory.

A separate reload memory is required for external subprograms executed in parallel.

Reset / end of program / power On

Reset and power ON cause external subprogram calls to be interrupted and the associated load memory to be deleted.

A subprogram selected for "Execution from external source" remains selected for "Execution from external source" after a reset / end of program. A power ON deletes the selection.

References

Further information on "Execution from external source" can be found in:

Function Manual, Basic Functions, Mode Group, Channel, Program Operation, Reset Behavior (K1)

1.25 Macro technique (DEFINE ... AS)

NOTICE
Complicated programming Use of macros can significantly alter the control's programming language. Macro technology may only be used with great care.

Function

A macro is a sequence of individual statements which have together been assigned a name of their own. G, M and H functions or L subprogram names can also be used as macros. When a macro is called during a program run, the statements programmed under the program name are executed one after the other.

Application

Statement sequences that are repeated are only programmed once as macro in a dedicated macro block (macro file) or once at the beginning of the program. The macro can then be called in any main program or subprogram and executed.

Activation

In order to use the macros of a macro file in the NC program, the macro file must be downloaded into the NC.

Syntax

Macro definition:
```
DEFINE <Macro name> AS <statement 1> <statement 2> ...
```
Call in the NC program:
```
<macro name>
```

Meaning

`DEFINE ... AS` :	Keyword combination to define a macro
`<macro name>`:	Macro name
	Only identifiers are permissible as macro names.
	The macro is called from the NC program using the macro name.
`<statement>`:	Programming statement that should be included in the macro.

Rules when defining a macro

- Any identifier, G, M, H functions and L program names can be defined in a macro.
- Macros can also be defined in the NC program.
- G function macros can only be defined in the macro module globally for the entire control (modal).
- H and L functions can be programmed with two digits.
- M and G functions can be programmed using three digits.

Note

Keywords and reserved names may not be redefined using macros.

Supplementary conditions

Nesting of macros is not possible.

Examples

Example 1: Macro definition at the beginning of the program

```
Program code                          Comment
DEFINE LINE AS G1 G94 F300            ; Macro definition
...
...
N70 LINE X10 Y20                      ; Macro call
...
```

Example 2: Macro definitions in a macro file

```
Program code                          Comment
DEFINE M6 AS L6                       ; A subprogram is called at tool change to handle
                                      the necessary data transfer. The actual M function
                                      is output in the subprogram (e.g. M106).
DEFINE G81 AS DRILL(81)               ; Emulation of the DIN G function.
DEFINE G33 AS M333 G333               ; During thread cutting, synchronization is
                                      requested with the PLC. The original G function G33
                                      was renamed to G333 by machine data so that the
                                      programming is identical for the user.
```

Example 3: External macro file

The macro file must be downloaded into the NC after reading the external macro file into the control. Only then can macros be used in the NC program.

```
Program code                          Comment
%_N_UMAC_DEF
;$PATH=/_N_DEF_DIR                   ; Customer-specific macros
DEFINE PI AS 3.14
DEFINE TC1 AS M3 S1000
DEFINE M13 AS M3 M7                   ; Spindle clockwise, coolant on
DEFINE M14 AS M4 M7                   ; Spindle counter-clockwise, coolant on
DEFINE M15 AS M5 M9                   ; Spindle stop, coolant off
DEFINE M6 AS L6                       ; Call tool change program
DEFINE G80 AS MCALL                   ; Deselect drilling cycle
M30
```

File and Program Management

2

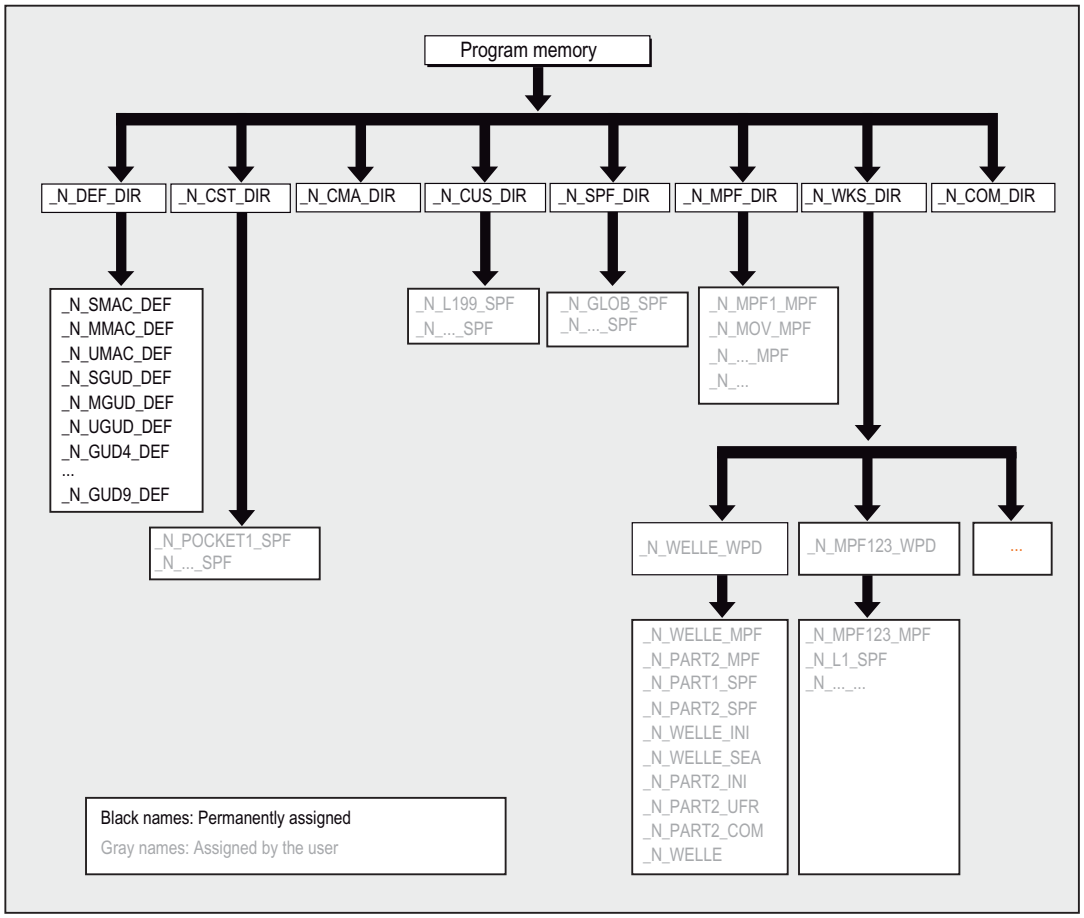
2.1 Program memory

Function

Files and programs (e.g. main programs and subprograms, macro definitions) are saved in the non-volatile program memory (→ passive file system).

References:
Function Manual, Extended Functions; Memory Configuration (S7)

A number of file types are also stored here temporarily; these can be transferred to the work memory as required (e.g. for initialization purposes when machining a specific workpiece).



Standard directories

Its standard complement of directories is as follows:

Directory	Contents
_N_DEF_DIR	Data modules and macro modules
_N_CST_DIR	Standard cycles
_N_CMA_DIR	Manufacturer cycles
_N_CUS_DIR	User cycles
_N_WKS_DIR	Workpieces
_N_SPF_DIR	Global subprograms
_N_MPF_DIR	Main programs
_N_COM_DIR	Comments

File types

The following file types can be stored in the main memory:

File type	Description
<name>_MPF	Main program
<name>_SPF	Subprogram
<name>_TEA	Machine data
<name>_SEA	Setting data
<name>_TOA	Tool offsets
<name>_UFR	Zero offsets/frames
<name>_INI	Initialization files
<name>_GUD	Global user data
<name>_RPA	R-parameters
<name>_COM	Comment
<name>_DEF	Definitions for global user data and macros

Workpiece main directory (_N_WKS_DIR)

The workpiece main directory exists in the standard setup of the program memory under the name _N_WKS_DIR. The workpiece main directory contains all the workpiece directories for the workpieces that you have programmed.

Workpiece directories (..._WPD)

To make data and program handling more flexible certain data and programs can be grouped together or stored in individual workpiece directories.

A workpiece directory contains all files required for machining a workpiece. These can be main programs, subprograms, any initialization programs and comment files.

The first time a part program is started, initialization programs are executed once, depending on the selected program (in accordance with machine data MD11280 $MN_WPD_INI_MODE).

Example:

The workpiece directory _N_WELLE_WPD, created for SHAFT workpiece contains the following files:

File	Description
_N_SHAFT_MPF	Main program
_N_PART2_MPF	Main program
_N_PART1_SPF	Subprogram
_N_PART2_SPF	Subprogram
_N_SHAFT_INI	General initialization program for the data of the workpiece
_N_SHAFT_SEA	Setting data initialization program
_N_PART2_INI	General initialization program for the data for the Part 2 program
_N_PART2_UFR	Initialization program for the frame data for the Part 2 program
_N_SHAFT_COM	Comment file

Creating workpiece directories on an external PC

The steps described below are performed on an external data station. Please refer to your Operator's Guide for file and program management (from PC to the control) directly on the control.

Creating a workpiece directory with a path name ($PATH=…)

The destination path `$PATH=…` is specified within the second line of the file. The file is then stored at the specified path.

Example:

Program code

```
%_N_SHAFT_MPF
;$PATH=/_N_WKS_DIR/_N_SHAFT_WPD
N10 G0 X… Z…
...
M2
```

File _N_WELLE_MPF is stored in directory /_N_WKS_DIR/_N_WELLE_WPD.

Creating a workpiece directory without a path name

If the path name is missing, files with the _SPF extension are stored in directory /_N_SPF_DIR, files with the _INI extension are stored in the RAM and all other files are stored in directory/_N_MPF_DIR.

Example:

```
Program code
%_N_SHAFT_SPF
...
M17
```

File _N_WELLE_SPF is stored in directory /_N_SPF_DIR.

Select workpiece for machining

A workpiece directory can be selected for execution in a channel. If a main program with the **same name** or only a single main program (_MPF) is stored in this directory, this is automatically selected for execution.

References:
Operating Manual

Search paths for subprogram call

If the search path is not specified explicitly in the part program when a subprogram (or initialization file) is called, the calling program searches in a fixed search path.

Subprogram call with absolute path

Example:

```
Program code
...
CALL"/_N_CST_DIR/_N_CYCLE1_SPF"
...
```

Subprogram call without absolute path

Programs are usually called without specifying a path.

Example:

```
Program code
...
CYCLE1
...
```

The directories are searched for the called program in the following sequence:

No.	Directory	Description
1	Current directory / *name*	Workpiece main directory or standard directory _N_MPF_DIR
2	Current directory / *name_SPF*	
3	Current directory / *name_MPF*	
4	/_N_SPF_DIR / *name_SPF*	Global subprograms
5	/_N_CUS_DIR / *name_SPF*	User cycles
6	/_N_CMA_DIR / *name_SPF*	Manufacturer cycles
7	/_N_CST_DIR / *name_SPF*	Standard cycles

Programming search paths for subprogram call (CALLPATH)

The CALLPATH part program command is used to extend the search path of a subprogram call.

Example:

```
Program code
CALLPATH ("/_N_WKS_DIR/_N_MYWPD_WPD")
...
```

The search path is stored in front of position 5 (user cycle) in accordance with the specified programming.

For further information on the programmable search path for subprogram calls with CALLPATH, see "Extend search path for subprogram calls (CALLPATH) (Page 197)".

2.2 Working memory (CHANDATA, COMPLETE, INITIAL)

Function

The working memory contains the current system and user data with which the control is operated (active file system), e.g.:

- Active machine data
- Tool offset data
- Zero offsets
- ...

Initialization programs

These are programs with which the working memory data is initialized. The following file types can be used for this:

File type	Description
name_TEA	Machine data
name_SEA	Setting data
name_TOA	Tool offsets
name_UFR	Zero offsets/frames
name_INI	Initialization files
name_GUD	Global user data
name_RPA	R-parameters

Data areas

The data can be organized in different areas in which they are to apply. For example, a control can have several channels or, as is commonly the case, several axes at its disposal.

There are:

Identifier	Data areas
NCK	NCK-specific data
CH<n>	Channel-specific data (<n> specifies the channel name)
AX<n>	Axis-specific data (<n> specifies the number of the machine axis)
TO	Tool data
COMPLETE	All data

Create initialization program at an external PC

The data area identifier and the data type identifier can be used to determine the areas which are to be treated as a unit when the data is saved:

_N_AX5_TEA_INI	Machine data for axis 5
_N_CH2_UFR_INI	Frames of channel 2
_N_COMPLETE_TEA_INI	All machine data

When the control is started up initially, a set of data is automatically loaded to ensure proper operation of the control.

Procedure for multi-channel controls (CHANDATA)

CHANDATA(<channel number>) for several channels is only permissible in the file _N_INITIAL_INI. This is the commissioning file with which all data of the control is initialized.

```
Program code                                Comment
%_N_INITIAL_INI
CHANDATA(1)
                                            ; Machine axis assignment, channel 1:
$MC_AXCONF_MACHAX_USED[0]=1
$MC_AXCONF_MACHAX_USED[1]=2
$MC_AXCONF_MACHAX_USED[2]=3
CHANDATA(2)
                                            ; Machine axis assignment, channel 2:
$MC_AXCONF_MACHAX_USED[0]=4
$MC_AXCONF_MACHAX_USED[1]=5
CHANDATA(1)
                                            ; Axial machine data:
                                            ; Exact stop window coarse:
$MA_STOP_LIMIT_COARSE[AX1]=0.2              ; Axis 1
$MA_STOP_LIMIT_COARSE[AX2]=0.2              ; Axis 2
                                            ; Exact stop window fine:
$MA_STOP_LIMIT_FINE[AX1]=0.01               ; Axis 1
$MA_STOP_LIMIT_FINE[AX1]=0.01               ; Axis 2
```

NOTICE

CHANDATA statement

In the part program, the CHANDATA statement may only be set for that channel in which the NC program is executed. This means the statement can be used to protect NC programs so that they are not executed in the wrong channel.

Program processing is aborted if an error occurs.

Note

INI files in job lists do not contain any CHANDATA statements.

Save initialization program (COMPLETE, INITIAL)

The files of the working memory can be saved on an external PC and then read in again from there.

- The files are saved with `COMPLETE`.
- `INITIAL` is used to create an INI file (_N_INITIAL_INI) over all areas.

Read-in initialization program

NOTICE
Data loss If the file is read-in with the name "INITIAL_INI", then all data that is not supplied in the file is initialized using standard data. Only machine data is an exception. This means that **setting data, tool data, ZO, GUD values, ...** are supplied with standard data (normally "ZERO").

For example, the file COMPLETE_TEA_INI is suitable for reading-in individual machine data. The control only expects machine data in this file. This is the reason that the other data areas remain unaffected in this case.

Loading initialization programs

The INI programs can also be selected and called as part programs if they only use data of one channel. This means that it is also possible to initialize program-controlled data.

Protection zones

3

3.1 Defining the protection zones (CPROTDEF, NPROTDEF)

Function

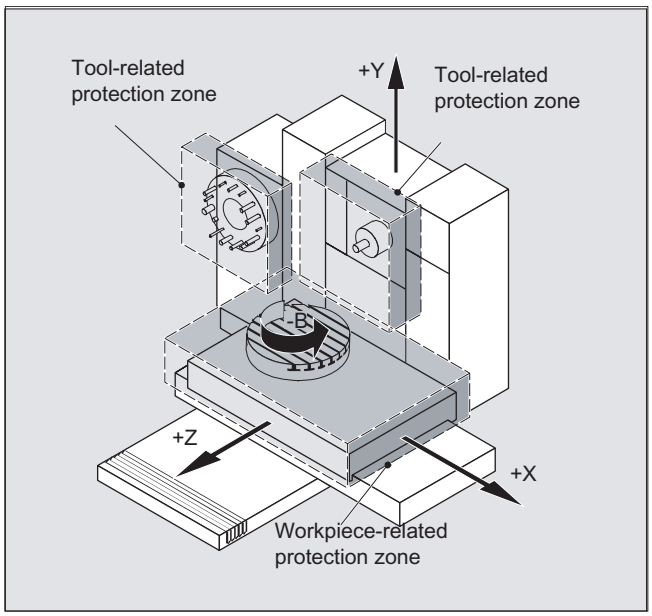
You can use protection zones to protect various elements on the machine, their components and the workpiece against incorrect movements.

Tool-oriented protection zones:

For parts that belong to the tool (e.g. tool, toolholder)

Workpiece-oriented protection zones:

For parts that belong to the workpiece (e.g. parts of the workpiece, clamping table, clamping shoe, spindle chuck, tailstock).



Syntax

```
DEF INT NOT_USED
G17/G18/G19
CPROTDEF/NPROTDEF(<n>,<t>,<applim>,<applus>,<appminus>)
G0/G1/... X/Y/Z...
...
EXECUTE(NOT_USED)
```

Meaning

DEF INT NOT_USED:	Define local variable of the INTEGER data type
G17/G18/G19:	The required plane is selected before CPROTDEF or NPROTDEF with G17/G18/G19 and must not be altered before EXECUTE. The applicate must not be programmed between CPROTDEF or NPROTDEF and EXECUTE.
CPROTDEF:	Define channel-specific protection zones
NPROTDEF:	Define machine-specific protection zones
G0/G1/... X/Y/Z... ...:	The contour of the protection zones is specified with up to 11 traversing movements in the selected plane. The first traversing movement is the movement to the contour. The valid protection zone is the zone left of the contour. **Note:** The travel motions programmed between CPROTDEF or NPROTDEF and EXECUTE are not executed, but merely define the protection area.
EXECUTE:	End definition
<n>:	Number of defined protection zone
<t>:	Type of protection zone TRUE: **Tool**-related protection zone FALSE: **Workpiece**-related protection zone
<applim>:	Type of limitation in the third dimension 0: No limitation 1: Limit in plus direction 2: Limit in minus direction 3: Limit in positive and negative direction
<applus>:	Value of the limit in the positive direction in the 3rd dimension
<appminus>:	Value of the limit in the negative direction in the 3rd dimension
NOT_USED:	Error variable has no effect for protection zones with EXECUTE

Supplementary conditions

During definition of the protection zones:

- No cutter or tool nose radius compensation must be active.
- No transformation must be active.
- No frame must be active.

Neither must reference point approach (G74), fixed point approach (G75), block preprocessing stop nor program end be programmed.

Further information

Definition of protection zones

Definition of the protection zones includes the following:

- `CPROTDEF` for channel-specific protection zones
- `NPROTDEF` for machine-specific protection zones
- Contour description for protection zone
- Termination of the definition with `EXECUTE`

You can specify a relative offset for the reference point of the protection zone when the protection zone is activated in the NC part program.

Reference point for contour description

The workpiece-oriented protection zones are defined in the basic coordinate system.

The tool-oriented protection zones are defined with reference to the tool carrier reference point F.

Permissible contour elements

The following are permissible to define the contour of the protection zone:

- `G0`, `G1` for straight contour elements
- `G2` for clockwise circle segments (only for workpiece-oriented protection zones)
- `G3` for circular segments in the counterclockwise direction

Note

If a full circle describes the protection zone, it must be divided into two half circles. The sequence `G2`, `G3` or `G3`, `G2` is not permitted. A short `G1` block must be inserted, if necessary.

The last point in the contour description must coincide with the first.

External protection zones

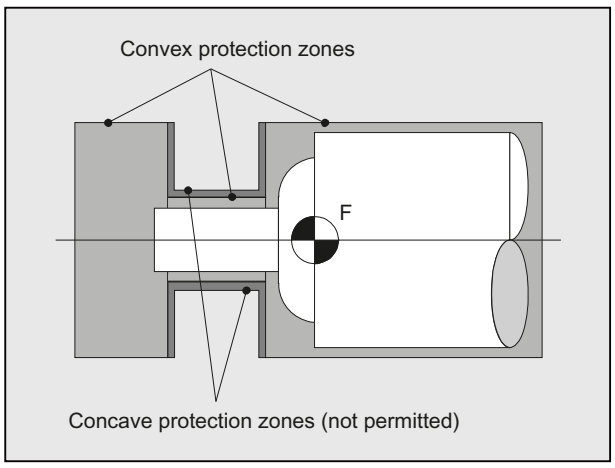
External protection zones (only possible for workpiece-related protection zones) must be defined in the clockwise direction.

Protection zones symmetrical around the center of rotation

For protection zones symmetrical around the axis or rotation (e.g. spindle chuck), you must describe the complete contour and not only up to the center of rotation!

Tool-related protection zones

Tool-related protection zones must always be convex. If a concave protected zone is desired, this should be subdivided into several convex protection zones.



3.2 Activating/deactivating protection zones (CPROT, NPROT)

Function

Activating and preactivating previously defined protection zones for collision monitoring and deactivating protection zones.

The maximum number of protection zones, which can be active simultaneously on the same channel, is defined in machine data.

If no toolrelated protection zone is active, the tool path is checked against the workpiece-related protection zones.

Note

If no workpiece-related protection zone is active, protection zone monitoring does not take place.

Syntax

```
CPROT(<n>,<state>,<xMov>,<yMov>,<zMov>)
NPROT(<n>,<state>,<xMov>,<yMov>,<zMov>)
```

Meaning

`CPROT`:	Call of channel-specific protection area
`NPROT`:	Call machine-specific protection zone
`<n>`:	Number of the protection zone

<state>:	Status parameter 0: Deactivate protection zone 1: Preactivate protection zone 2: Activate protection zone 3: Preactivate protection zone with conditional stop
<xMov>,<yMov>,<zMov>:	Move defined protection zone on the geometry axes

Supplementary conditions

Protection zone monitoring for active tool radius compensation

For active tool radius compensation, a functioning protection zone monitoring is only possible if the plane of the tool radius compensation is identical to the plane of the protection zone definitions.

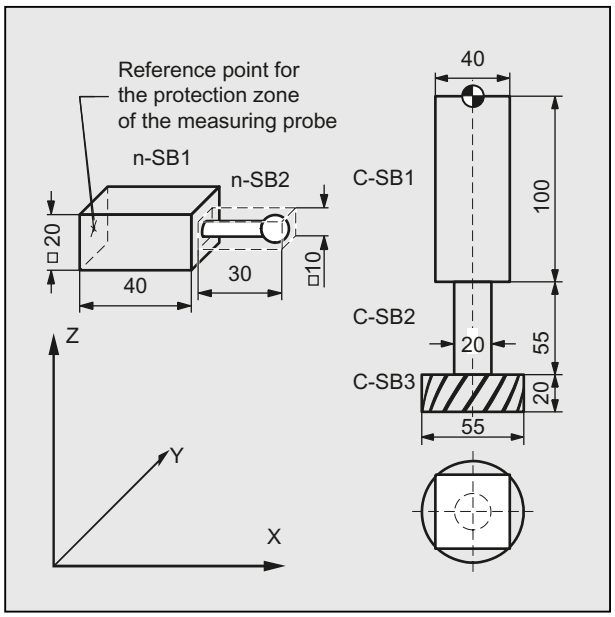
Example

Possible collision of a milling cutter with the measuring probe is to be monitored on a milling machine. The position of the measuring probe is to be defined by an offset when the function is activated. The following protection zones are defined for this:

- A machine-specific and a workpiece-related protection zone for both the measuring probe holder (n-SB1) and the measuring probe itself (n-SB2).
- A channel-specific and a tool-oriented protection zone for the milling cutter holder (c-SB1), the cutter shank (c-SB2) and the milling cutter itself (c-SB3).

The orientation of all protection zones is in the Z direction.

The position of the reference point of the measuring probe on activation of the function must be X = -120, Y = 60 and Z = 80.



Program code	**Comment**
DEF INT PROTECTB	; Definition of a Help variable
Definition of protection zone G17	; Set orientation
NPROTDEF(1,FALSE,3,10,-10)G01 X0 Y-10	; Protection zone n-SB1
X40	
Y10	
X0	
Y-10	
EXECUTE(PROTECTB)	
NPROTDEF(2,FALSE,3,5,-5)	; Protection zone n-SB2
G01 X40 Y-5	
X70	
Y5	
X40	
Y-5	
EXECUTE(PROTECTB)	
CPROTDEF(1,TRUE,3,0,-100)	; Protection zone c-SB1
G01 X-20 Y-20	
X20	
Y20	
X-20	
Y-20	
EXECUTE(PROTECTB)	
CPROTDEF(2,TRUE,3,-100,-150)	; Protection zone c-SB2
G01 X0 Y-10	
G03 X0 Y10 J10	
X0 Y-10 J-10	
EXECUTE(PROTECTB)	
CPROTDEF(3,TRUE,3,-150,-170)	; Protection zone c-SB3
G01 X0 Y-27.5	
G03 X0 Y27,5 J27.5	
X0 Y27.5 J-27.5	
EXECUTE(PROTECTB)	
Activation of protection zones:	
NPROT(1,2,-120,60,80)	; Activate protection zone n-SB1 with offset
NPROT(2.2,-120,60,80)	; Activate protection zone n-SB2 with offset
CPROT(1,2,0,0,0)	; Activate protection zone c-SB1 with offset
CPROT(2,2,0,0,0)	; Activate protection zone c-SB2 with offset
CPROT(3,2,0,0,0)	; Activate protection zone c-SB3 with offset

Further information

Activation status (<state>)

- **<state>=2**

  A protection zone is generally activated in the part program with status = 2.

  The status is always channel-specific even for machine-oriented protection zones.

- **<state>=1**

  If a PLC user program provides for a protection zone to be effectively set by a PLC user program, the required preactivation is implemented with status = 1.

- **<state>=3**

  In the case of preactivation with conditional stop, the system never stops in front of a preactivated protection zone which has been violated. The stop only occurs if the protection zone has been activated. This facilitates uninterrupted processing if the protection zones have only been activated in special cases. N.B. The system may move into the protection zone as a result of the braking ramp if the protection zone is only activated immediately prior to motion.

  Preactivation with conditional stop is realized using status = 3.

- **<state>=0**

  The protection zones are deactivated and therefore disabled with Status = 0. No shift is required

Movement of protection zones for (pre)activating

The offset can take place in 1, 2, or 3 dimensions. The offset refers to:

- the machine zero in workpiece-specific protection zones.
- the tool carrier reference point F in tool-specific protection zones.

Status after booting

Protection zones can be activated straight after booting and subsequent reference point approach. The system variable $SN_PA_ACTIV_IMMED[<n>] or $SC_PA_ACTIV_IMMED[<n>] must be set to TRUE for this purpose. They are always activated with Status = 2 and have no offset.

Multiple activation of protection zones

A protection zone can be active simultaneously in several channels (e.g. tailstock where there are two opposite sides). The protection zones are only monitored if all geometry axes have been referenced.

The following applies:

- The protection zone cannot be activated simultaneously with different offsets in a single channel.
- Machine-oriented protection zones must have the same orientation on both channels.

3.3 Checking for protection zone violation, working area limitation and software limit switches (CALCPOSI)

Function

As of the start position, the `CALCPOSI()` function checks whether active limits have been violated along the traversing distance in the workpiece coordinate system (WCS) with regard to the **geometry axes**.

If the distance cannot be fully traversed because of limits, a positive, decimal-coded status value and the maximum possible traversing distance are returned.

Syntax

```
<Status> = CALCPOSI(VAR <Start>, VAR <Dist>, VAR <Limit>, VAR
<MaxDist>, <System>, <TestLim>)
```

Meaning

`CALCPOSI`:	Test for limit violations with regard to the geometry axes.	
	Preprocessing stop:	No
	Alone in the block:	Yes
`<Status>`: (Part 1)	Function return value. Negative values indicate error states.	
	Data type:	INT
	Range of values:	-8 ≤ x ≤ 100000
	Values	**Meaning**
	0	The distance can be traversed completely.
	-1	At least one component is negative in <Limit>.
	-2	Error in a transformation calculation. Example: The traversing distance passes through a singularity so that the axis positions cannot be defined.
	-3	The specified traversing distance <Dist> and the maximum possible traversing distance <MaxDist> are linearly dependent. **Note** Can only occur in conjunction with <TestLim>, bit 4 == 1.
	-4	The projection of the traversing direction contained in <Dist> on to the limitation surface is the zero vector, or the traversing direction is perpendicular to the violated limitation surface. **Note** Can only occur in conjunction with <TestLim>, bit 5 == 1.
	-5	In <TestLim>, bit 4 == 1 AND bit 5 == 1
	-6	At least one machine axis that has to be considered for checking the traversing limits has not been homed.
	-7	Collision avoidance function: Invalid definition of the kinematic chain or the protection zones.
	-8	Collision avoidance function: This command cannot be executed because of insufficient memory.

<Status>: (Part 2)	Units digit **Note** If several limits are violated simultaneously, the limit with the greatest restriction on the specified traversing distance is signaled.	
	1	Software limit switches are limiting the traversing distance
	2	Working area limits are limiting the traversing distance
	3	Protection zones are limiting the traversing distance
	Tens digit	
	1x	The initial value violates the limit
	2x	The specified straight line violates the limit. This value is also returned if the end point does not violate any limit itself, but the path from the starting point to the end point would cause a limit value to be violated (e.g. by passing through a protection zone, curved software limit switches in the WCS for non-linear transformations, e.g. transmit).
<Status>: (Part 3)	Hundreds digit	
	1xx	AND units digit == 1 or 2: The positive limit value has been violated.
		AND units digit == 3 [1]: An NC-specific protection zone has been violated.
	2xx	AND units digit == 1 or 2: The negative limit value has been violated.
		AND units digit == 3 [1]: A channel-specific protection zone has been violated.
<Status>: (Part 4)	Thousands digit	
	1xxx	AND units digit == 1 or 2: Factor, with which the axis number is multiplied, that violates the limit. Numbering of the axes begins with 1. Reference: • Software limit switch: Machine axes • Working area limitation: Geometry axes AND units digit == 3 [1]: Factor with which the number of the violated protection zone is multiplied.

<Status>: (Part 5)	Hundred thousands digit	
	0xxxxx	Hundred thousands digit == 0: <Dist> remains unchanged
	1xxxxx	A direction vector is returned in <Dist> which defines the further motion direction on the limitation surface. Can only occur with the following supplementary conditions: • Software limit switch or working area limit violated (not in the starting point) • A transformation is **not** active • <TestID>, bit 4 or bit 5 == 1
	1) If several protection zones are violated, the protection zone with the greatest restriction on the specified traversing distance is signaled.	
<Start>:	Reference to a vector with the start positions: • <Start> [0]: Abscissa • <Start> [1]: Ordinate • <Start> [2]: Applicate	
	Parameter type:	Input
	Data type:	VAR REAL [3]
	Range of values:	-max. REAL value ≤ x[n] ≤ +max. REAL value
<Dist>:	Reference to a vector with the incremental traversing distance: • <Dist> [0]: Abscissa • <Dist> [1]: Ordinate • <Dist> [2]: Applicate	
	For set hundred thousands digit in <Status>:	
	<Dist> contains a unit vector **v** as output value, which defines the further traversing direction in the WCS.	
	Case 1: Formation of vector **v** for <TestID>, bit 4 == 1 The input vectors <Dist> and <MaxDist> span the motion plane. This plane is cut by the violated limitation surface. The intersecting line of the two planes defines the direction of vector **v**. The orientation (sign) is selected so that the angle between the input vector <MaxDist> and **v** is not greater than 90 degrees.	
	Case 2: Formation of vector **v** for <TestID>, bit 5 == 1 Vector **v** is the unit vector in the projection direction of the traversing vector contained in <Dist> on the limitation surface. If the projection of the traversing vector on the limitation surface is the zero vector, an error is returned.	
	Parameter type:	Input/output
	Data type:	VAR REAL [3]
	Range of values:	-max. REAL value ≤ x[n] ≤ +max. REAL value

<Limit>:	Reference to an array of length 5. • <Limit> [0 - 2]: Minimum clearance of the geometry axes, abscissa, ordinate, applicate The first three elements include the minimum clearances of the geometry axis, which must be maintained with respect to the monitored limits. Regarding the working area limitation they are always used – and regarding the software limit switch they are used when no transformation is active, or a transformation is active in which a clear assignment of the geometry axes to the linear machine axes is possible, e.g. 5-axis transformations. • <Limit> [3]: Contains the minimum clearance for linear machine axes which, for example, cannot be assigned a geometry axis because of a non-linear transformation. This value is also used as limit value for the monitoring of the conventional protection zones and the collision avoidance protection zones. • <Limit> [4]: Contains the minimum clearance for rotary machine axes which, for example, cannot be assigned a geometry axis because of a non-linear transformation. **Note** This value is only active for the monitoring of the software limit switches for special transformations.	
	Parameter type:	Input
	Data type:	VAR REAL [5]
	Range of values:	-max. REAL value ≤ x[n] ≤ +max. REAL value
<MaxDist>:	Reference to a vector with the incremental traversing distance in which the specified minimum clearance of an axis limit is not violated by any of the relevant machine axes: • <Dist> [0]: Abscissa • <Dist> [1]: Ordinate • <Dist> [2]: Applicate If the traversing distance is not restricted, the contents of this return parameter are the same as the contents of <Dist>.	
	With <TestID>, bit 4 == 1: <Dist> and <MaxDist> <MaxDist> and <Dist> must contain vectors as input values that span a motion plane. The two vectors must be mutually linearly dependent. The absolute value of <MaxDist> is arbitrary. For the calculation of the motion direction, see the description for <Dist>.	
	Parameter type:	Output
	Data type:	VAR REAL [3]
	Range of values:	-max. REAL value ≤ x[n] ≤ +max. REAL value

<System>:	Measuring system (inch/metric) for position and distance specifications (**optional**)		
	Data type:		BOOL
	Default value:		FALSE
	Value		**Meaning**
	FALSE		Measuring system corresponding to the currently active G function from G group 13 (G70, G71, G700, G710). **Note** If G70 is active and the basic system is metric (or G71 is active and the basic system is inch), the system variables $AA_IW and $AA_MW are provided in the basic system and, if used, must be converted for CALCPOSI().
	TRUE		Measuring system corresponding to the set basic system: MD52806 $MN_ISO_SCALING_SYSTEM
<TestLim>:	Bit-coded selection of the limits to be monitored (**optional**)		
	Data type:		INT
	Default value:		Bit 0, 1, 2, 3 == 1 (15)
	Bit	**Decimal**	**Meaning**
	0	1	Software limit switch
	1	2	Working area limitation
	2	4	Activated conventional protection zones
	3	8	Preactivated conventional protection zones
	4	16	With violated software limit switches or working area limits in <Dist>, return the traversing direction as in **Case 1**.
	5	32	With violated software limit switches or working area limits in <Dist>, return the traversing direction as in **Case 2**.
	6	64	Activated collision avoidance protection zones
	7	128	Preactivated collision avoidance protection zones
	8	256	Pairs of activated and preactivated collision avoidance protection zones

References

Function Manual, Basic Functions, (A3) Axis Monitoring, Protection Zones, Chapter "Protection zones"

Special motion commands

4

4.1 Approaching coded positions (CAC, CIC, CDC, CACP, CACN)

Function

You can traverse linear and rotary axes via position numbers to fixed axis positions saved in machine data tables using the following commands. This type of programming is called "approach coded positions".

Syntax

```
CAC(<n>)
CIC(<n>)
CACP(<n>)
CACN(<n>)
```

Meaning

`CAC(<n>)`	Approach coded position from position number n
`CIC(<n>)`	Starting from the actual position number, approach the coded position n position locations before (+n) or back (–n)
`CDC(<n>)`	Approach the position from position number n along the shortest path (only for rotary axes)
`CACP(<n>)`	Approach coded position from position number n in the positive direction (only for rotary axes)
`CACN(<n>)`	Approach coded position from position number n in the negative direction (only for rotary axes)
`<n>`	Position number within the machine data table Range of values: 0, 1, … (max. number of table locations - 1)

Example: Approach coded positions of a positioning axis

```
Programming code                Comment
N10 FA[B]=300                   ; Feedrate for positioning axis B
N20 POS[B]=CAC(10)              ; Approach coded position from position number 10
N30 POS[B]=CIC(-4)              ; Approach coded position from "current position
                                  number" - 4
```

References

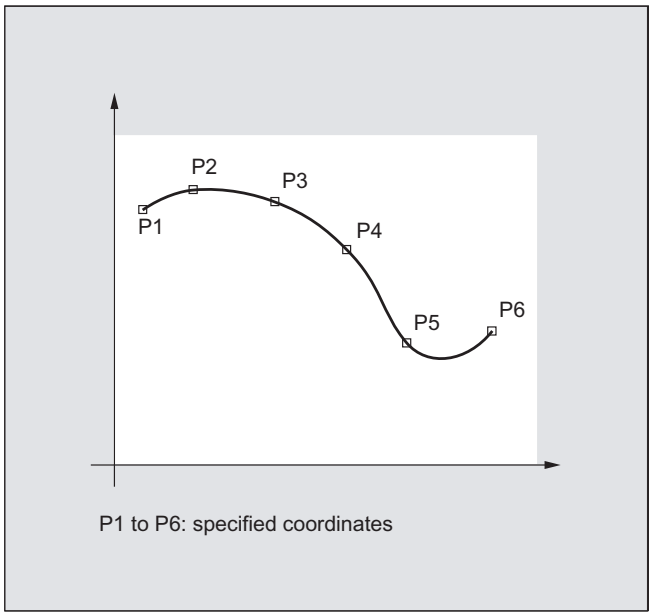
- Function Manual Expanded Functions; Indexing Axes (T1)
- Function Manual, Synchronized Actions

4.2 Spline interpolation (ASPLINE, BSPLINE, CSPLINE, BAUTO, BNAT, BTAN, EAUTO, ENAT, ETAN, PW, SD, PL)

Function

Randomly curved workpiece contours cannot be precisely defined in an analytic form. This is the reason why these type of contours are approximated using a limited number of points along curves, e.g. when digitizing surfaces. The points along the curve must be connected to define a contour in order to generate the digitized surface of a workpiece. Spline interpolation permits this.

A spline defines a curve which is formed from polynomials of 2nd or 3rd degree. The characteristics of the points along the curve of a spline can be defined **depending on the spline type being used**.



For SINUMERIK solution line, the following spline types are available:

- A spline
- B spline
- C spline

Syntax

General:

```
ASPLINE X... Y... Z... A... B... C...
BSPLINE X... Y... Z... A... B... C...
CSPLINE X... Y... Z... A... B... C...
```

For a B spline, the following can be additionally programmed:

```
PW=<n>
SD=2
PL=<value>
```

For A and C splines, the following can be additionally programmed:

`BAUTO` / `BNAT` / `BTAN`

`EAUTO` / `ENAT` / `ETAN`

Meaning

Spline interpolation type:

`ASPLINE`	Command to activate A spline interpolation
`BSPLINE`	Command to activate B spline interpolation
`CSPLINE`	Command to activate C spline interpolation
	The `ASPLINE`, `BSPLINE` and `CSPLINE` commands are modally effective and belong to the group of motion commands.

Points along a curve and check points:

`X... Y... Z...` `A... B... C...`	Positions in Cartesian coordinates

Point weight (only B spline):

`PW`	Using the `PW` command, a so-called "point weight" can be programmed for every point along the curve.		
`<n>`	"Point weight"		
	Range of values:	0 ≤ n ≤ 3	
	Increment:	0.0001	
	Effect:	n > 1	The checkpoint attracts the curve more significantly.
		n < 1	The checkpoint attracts the curve less significantly.

Spline degree (only B spline):

`SD`	A third degree polygon is used as standard, However, a second degree polygon can also be used by programming `SD=2`.

Distance between nodes (only B spline):

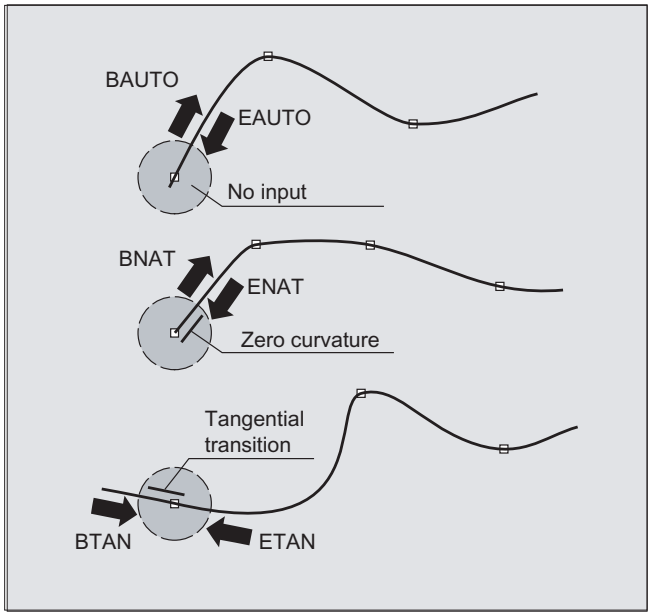
`PL`	The distances between nodes are suitably calculated internally. The controller can also machine pre-defined node clearances that are specified in the so-called parameter-interval-length using the `PL` command.
`<value>`	Parameter interval length
	Range of values: As for path dimension

Transitional behavior at the start of the spline curve (only A or C spline):

`BAUTO`	No specifications for the transitional behavior. The start is determined by the position of the first point.
`BNAT`	Zero curvature
`BTAN`	Tangential transition to the previous block (delete position)

Transitional behavior at the end of the spline curve (only A or C spline):

`EAUTO`	No specifications for the transitional behavior. The end is determined by the position of the last point.
`ENAT`	Zero curvature
`ETAN`	Tangential transition to the previous block (delete position)



Note

The programmable transitional behavior has no influence on the B spline. The B spline is always tangential to the check polygon at its start and end points.

Supplementary conditions

- Tool radius compensation may be used.
- Collision monitoring is carried out in the projection in the plane.

Examples

Example 1: B spline

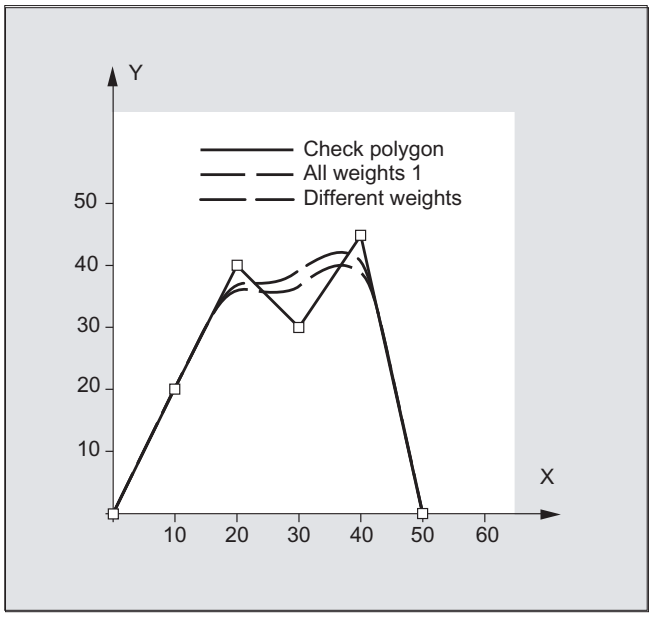
Program code 1 (all weights 1)

```
N10 G1 X0 Y0 F300 G64
N20 BSPLINE
N30 X10 Y20
N40 X20 Y40
N50 X30 Y30
N60 X40 Y45
N70 X50 Y0
```

Program code 2 (different weights)

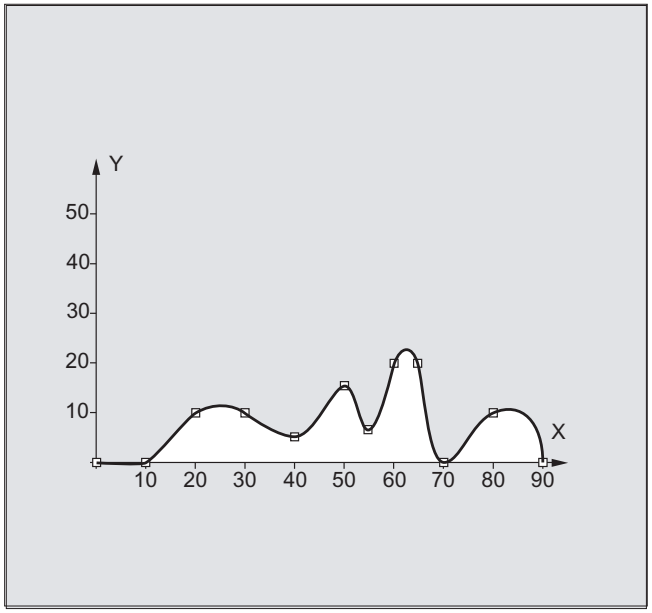
```
N10 G1 X0 Y0 F300 G64
N20 BSPLINE
N30 X10 Y20 PW=2
N40 X20 Y40
N50 X30 Y30 PW=0.5
N60 X40 Y45
N70 X50 Y0
```

Program code 3 (check polygon)	Comment
N10 G1 X0 Y0 F300 G64	
N20	; N/A
N30 X10 Y20	
N40 X20 Y40	
N50 X30 Y30	
N60 X40 Y45	
N70 X50 Y0	



Example 2: C spline, zero curvature at the start and at the end

```
Program code
N10 G1 X0 Y0 F300
N15 X10
N20 BNAT ENAT
N30 CSPLINE X20 Y10
N40 X30
N50 X40 Y5
N60 X50 Y15
N70 X55 Y7
N80 X60 Y20
N90 X65 Y20
N100 X70 Y0
N110 X80 Y10
N120 X90 Y0
N130 M30
```



Example 3: Spline interpolation (A spline) and coordinate transformation (ROT)

Main program:

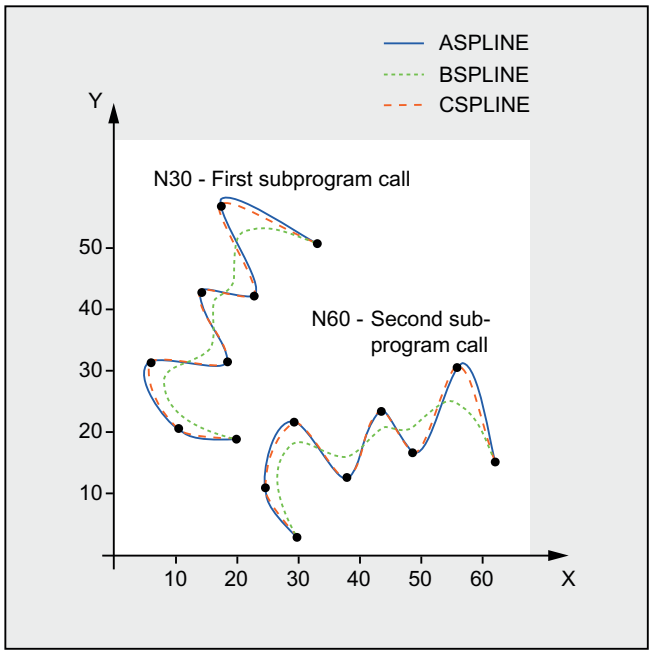
Program code	Comment
N10 G00 X20 Y18 F300 G64	; Approach starting point.
N20 ASPLINE	; Activate interpolation type A spline.
N30 CONTOUR	; First subprogram call.
N40 ROT Z-45	; Coordinate transformation: Rotation of the WCS through -45° around the Z axis.
N50 G00 X20 Y18	; Approach contour starting point.

Program code	Comment
N60 CONTOUR	; Second subprogram call.
N70 M30	; End of program

Subprogram "contour" (includes the coordinates of the points along the curve):

Program code
N10 X20 Y18
N20 X10 Y21
N30 X6 Y31
N40 X18 Y31
N50 X13 Y43
N60 X22 Y42
N70 X16 Y58
N80 X33 Y51
N90 M1

In addition to the spline curve, resulting from the example program (ASPLINE), the following diagram also contains the spline curves that would have been obtained when activating either B or C spline interpolation (BSPLINE, CSPLINE):



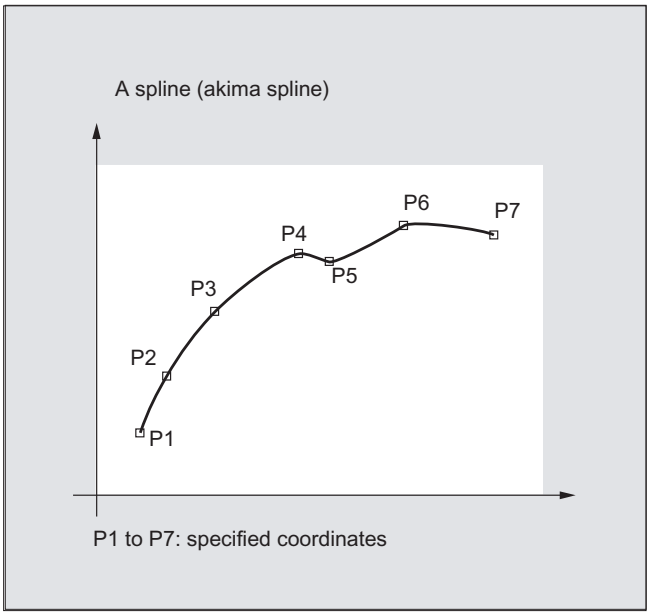
Further Information

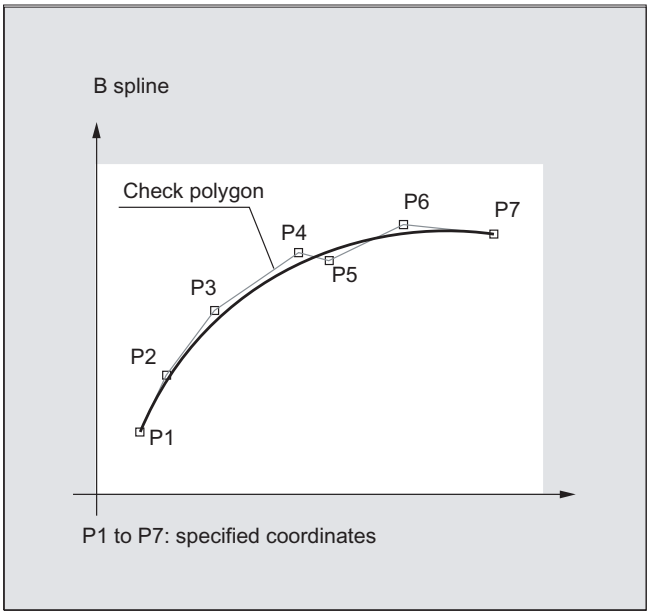
Advantages of spline interpolation

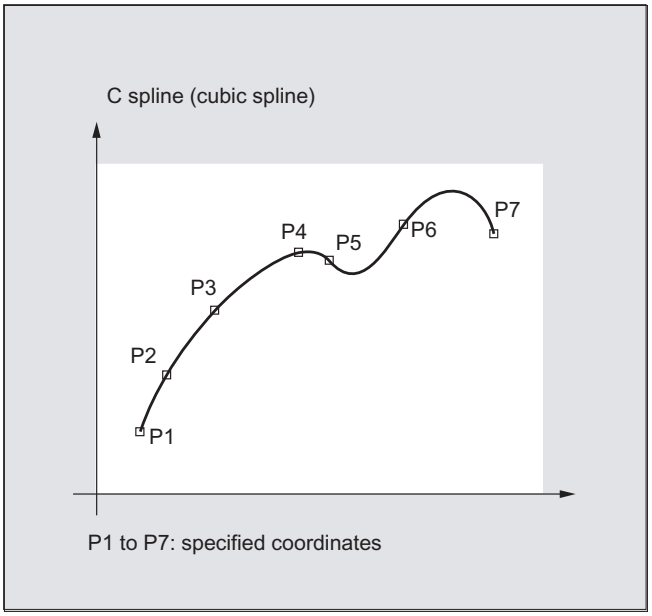
By using spline interpolation, the following advantages can be obtained contrary to using straight line blocks `G01`:

- The number of part program blocks required to describe the contour are reduced
- Soft, curve characteristics that reduce the stress on the mechanical system at transitions between part program blocks.

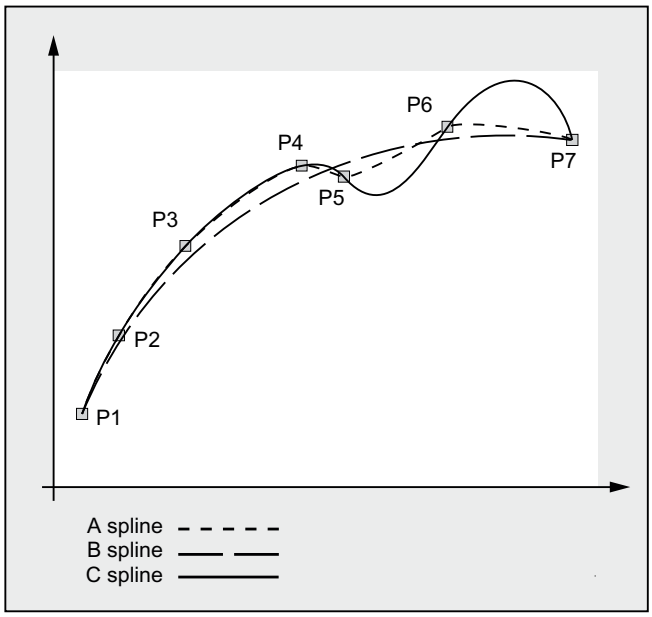
Properties and use of the various spline types

Spline type	Properties and use
A spline	 **Properties:** • The passes precisely through the specified intermediate points along the curve. • The curve characteristic is tangential, but does not have continuous curvature. • Produces hardly any undesirable oscillations. • The area of influence of changes to intermediate points along the curve is local. This means that a change to an intermediate point along the curve only affects up to max. 6 adjacent intermediate points. **Application:** The A spline is especially suitable for interpolating curves with large changes in the gradient (e.g. staircase-type curves and characteristics).

Spline type	Properties and use
B spline	 **Features:** • Does not run through the specified intermediate points along the curve, but only close to them. The intermediate points to not attract the curve. The curve characteristic can be additionally influenced by weighting the intermediate points using a factor. • The curve characteristic is tangential with continuous curvature. • Does not generate any undesirable oscillations. • The area of influence of changes to intermediate points along the curve is local. This means that a change to an intermediate point along the curve only affects up to max. 6 adjacent intermediate points. **Application:** Their B spline is primarily intended as interface to CAD systems.

Spline type	Properties and use
C spline	 **Features:** • The passes precisely through the specified intermediate points along the curve. • The curve characteristic is tangential with continuous curvature. • Frequently generates undesirable oscillations, especially at positions where the gradient changes significantly. • The area of influence of changes to the intermediate points is global. This means that if an intermediate point is changed then this influences the complete curved characteristic. **Application:** The C spline can be well used if the intermediate points lie on a curve that can be analytically calculated defined (circle, parabola, hyperbola).

Comparison of three spline types with identical interpolation points



Minimum number of spline blocks

The G codes ASPLINE, BSPLINE and CSPLINE link block end points with splines. For this purpose, a series of blocks (end points) must be simultaneously calculated. The buffer size for calculations is ten blocks as standard. Not every piece of block information is a spline end point. However, the controller needs a certain number of spline end-point blocks for every 10 blocks:

Spline type	Minimum number of spline blocks
A spline:	At least **4** blocks out of every 10 must be spline blocks. These do not include comment blocks or parameter calculations.
B spline:	At least **6** blocks out of every 10 must be spline blocks. These do not include comment blocks or parameter calculations.
C spline:	The required minimum number of spline blocks is the result of the following sum: Value of MD20160 $MC_CUBIC_SPLINE_BLOCKS + 1 The number of points used to calculate the spline segment is entered in MD20160. The default setting is 8. As standard, at least **9** blocks out of every 10 must be spline blocks.

Note

An alarm is output if the tolerated value is undershot and likewise when one of the axes involved in the spline is programmed as a positioning axis.

Combine short spline blocks

Spline interpolation can result in short spline blocks, which reduce the path velocity unnecessarily. The "Combine short spline blocks" function allows you to combine these blocks such that the resulting block length is sufficient and does not reduce the path velocity.

The function is activated via the channel-specific machine data:

MD20488 $MC_SPLINE_MODE (setting for spline interpolation).

References:
Function Manual, Basic Functions; Continuous-Path Mode, Exact Stop, Look Ahead (B1), Chapter: Combine short spline blocks

4.3 Spline group (SPLINEPATH)

Function

The axes to be interpolated in the spline group are selected using the `SPLINEPATH` command. Up to eight path axes can be involved in a spline interpolation grouping.

Note

If `SPLINEPATH` is not explicitly programmed, then the first three axes of the channel are traversed as spline group.

Syntax

The spline group is defined in a separate block:

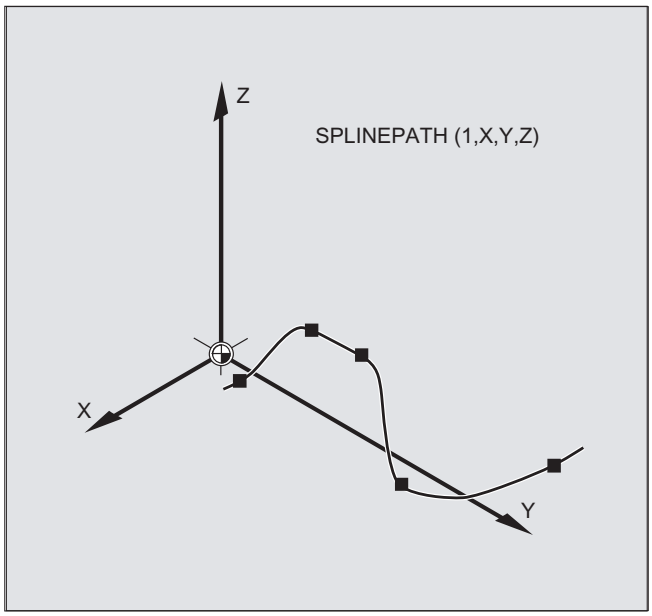
```
SPLINEPATH(n,X,Y,Z,…)
```

Meaning

`SPLINEPATH`	Command to define a spline group
`n`	=1 (fixed value)
`X,Y,Z,…`	Identifier of the path axes to be interpolated in the spline group

Example: Spline group with three path axes

```
Program code                                          Comment
N10 G1 X10 Y20 Z30 A40 B50 F350
N11 SPLINEPATH(1,X,Y,Z)                               ; Spline group
N13 CSPLINE BAUTO EAUTO X20 Y30 Z40 A50 B60           ; C spline
N14 X30 Y40 Z50 A60 B70                               ; Intermediate points
…
N100 G1 X… Y…                                         ; Deselect spline
                                                        interpolation
```



4.4 NC block compression (COMPON, COMPCURV, COMPCAD, COMPOF)

Function

CAD/CAM systems normally produce linear blocks, which meet the configured accuracy specifications. In the case of complex contours, a large volume of data and short path sections can result. The short path sections restrict the processing rate.

By using a compressor function, the contour, specified by using linear blocks, is approached using polynomial blocks. This has the following advantages:

- Reduction of the number of required part program blocks for describing the workpiece contour
- Continuous block transitions
- Higher maximum path velocities

The following compressor functions are available:

- COMPON

  The block transitions are only constant in the **velocity,** while acceleration of the participating axes can be in jumps at block transitions.

- COMPCURV

  Block transitions have **continuous acceleration**. This ensures both smooth velocity and acceleration of all axes at block transitions.

- COMPCAD

  The compression that uses a lot of computation time and memory space is optimized regarding surface quality and speed. COMPCAD should only be used if measures to improve the surface cannot be taken by the CAD/CAM program in advance.

`COMPOF` terminates the compressor function.

Syntax

```
COMPON
COMPCURV
COMPCAD
COMPOF
```

Meaning

`COMPON`:	Command to activate the compressor function COMPON.
	Effective: Modal
`COMPCURV`:	Command to activate the compressor function COMPCURV.
	Effective: Modal
`COMPCAD`:	Command to activate the compressor function COMPCAD.
	Effective: Modal
`COMPOF` :	Command to deactivate the currently active compressor function.

Note

The rounding function `G642` and jerk limitation `SOFT` can be used to achieve further improvements in surface quality. These commands must be written at the beginning of the program.

Supplementary conditions

- The NC block compression is generally executed for linear blocks (G1).
- Only blocks that comply with a simple syntax are compressed:

  N... G1X... Y... Z... F... ;comment

  All other blocks are executed unchanged (no compression).
- Motion blocks with extended addresses such as C=100 or A=AC(100) are also condensed.
- The position values do not have to be programmed directly, but can also be indirectly specified using parameter assignments, e.g. X=R1*(R2+R3).
- If the option "orientation transformation" is available, then NC blocks in which the tool orientation (and where relevant, also the tool rotation) is programmed using direction vectors can also be compressed (see "Compressing the orientation (Page 342)").
- It is interrupted by any other type of NC instruction, e.g., an auxiliary function output.

Examples

Example 1: COMPON

Program code	Comment
N10 COMPON	; Compressor function COMPON on.
N11 G1 X0.37 Y2.9 F600	; G1 before end point and feed.
N12 X16.87 Y-.698	
N13 X16.865 Y-.72	
N14 X16.91 Y-.799	
…	
N1037 COMPOF	; Compressor function off.
…	

Example 2: COMPCAD

Program code	Comment
G00 X30 Y6 Z40	
G1 F10000 G642	; Blending function G642 on.
SOFT	; Jerk limiting SOFT on.
COMPCAD	; Compressor function COMPCAD on.
STOPFIFO	
N24050 Z32.499	
N24051 X41.365 Z32.500	
N24052 X43.115 Z32.497	

```
Program code                          Comment
N24053 X43.365 Z32.477
N24054 X43.556 Z32.449
N24055 X43.818 Z32.387
N24056 X44.076 Z32.300
…
COMPOF                                ; Compressor function off.
G00 Z50
M30
```

References

Function Manual, Basic Functions; Continuous-Path Mode, Exact Stop, Look Ahead (B1), Section: "NC block compression"

4.5 Polynomial interpolation (POLY, POLYPATH, PO, PL)

Function

It actually involves a polynomial interpolation (POLY) and not a spline interpolation type. Its main purpose is to act as an interface for programming externally generated spline curves where the spline sections can be programmed directly.

This mode of interpolation relieves the NC of the task of calculating polynomial coefficients. It can be optimally applied in cases where the coefficients are supplied directly by a CAD system or post processor.

Syntax

3rd degree polynomial:

```
POLY PO[X]=(xe,a2,a3) PO[Y]=(ye,b2,b3) PO[Z]=(ze,c2,c3) PL=n
```

5th degree polynomial and new polynomial syntax:

```
POLY X=PO(xe,a2,a3,a4,a5) Y=PO(ye,b2,b3,b4,b5) Z=PO(ze,c2,c3,c4,c5)
PL=n
POLYPATH("AXES","VECT")
```

Note

The sum of the polynomial coefficients and axes programmed in an NC block must not exceed the maximum permitted number of axes per block.

Meaning

`POLY` :	Activation of polynomial interpolation with a block containing POLY.
`POLYPATH` :	Polynomial interpolation can be selected for both AXIS or VECT axis groups
`PO[axis identifier/variable]` :	End points and polynomial coefficients
`X, Y, Z`:	Axis identifier
`xe, ye, ze` :	Specification of end position for the particular axis; value range as for path dimension
`a2, a3, a4, a5` :	The coefficients a_2, a_3, a_4, and a_5 are written with their value; value range as for path dimension. The last coefficient in each case can be omitted if it equals zero.
`PL` :	Length of the parameter interval where polynomials are defined (definition range of the function f(p)). The interval always starts at 0, p can assume values from 0 to PL. Theoretical value range for PL: 0.0001 … 99 999.9999 **Note:** The PL value applies to the block in which it is located. If no PL is programmed, then PL=1 is applied.

Activating/deactivating polynomial interpolation

The polynomial interpolation is activated in the part program using the `POLX` G command.

The `POLY` G command together with `G0`, `G1`, `G2`, `G3`, `ASPLINE`, `BSPLINE` and `CSPLINE` belong to the 1st group.

Axes, which are only programmed with name and end point (e.g. `X10`), are linearly moved. If all axes of an NC block are programmed in this way, the controller behaves the same as for G1.

The polynomial interpolation is implicitly deactivated again by programming another command of the 1st G group `G0`, `G1`).

Polynomial coefficient

The `PO` value `(PO[]=)` or `...=PO(...)` specifies all polynomial coefficients for an axis. Several values are specified, separated by commas corresponding the degree of the polynomial. Different degrees of polynomials are possible for various axes within one block.

POLYPATH subprogram

Using `POLYPATH(...)`, the polynomial interpolation can be selectively released for certain axis groups:

Only path axes and supplementary axes:	`POLYPATH("AXES")`
Only orientation axes: (when moving with orientation transformation)	`POLYPATH("VECT")`

The axes that are not released are linearly moved.

Polynomial interpolation is enabled as standard for both axis groups.

Polynomial interpolation is deactivated for all axes by programming without the `POLYPATH( )` parameter.

Example

```
Program code                                                    Comment
N10 G1 X… Y… Z… F600
N11 POLY PO[X]=(1,2.5,0.7) PO[Y]=(0.3,1,3.2) PL=1.5             ; Polynomial interpolation on
N12 PO[X]=(0,2.5,1.7) PO[Y]=(2.3,1.7) PL=3
...
N20 M8 H126 …
N25 X70 PO[Y]=(9.3,1,7.67) PL=5                                 ; Mixed data for the axes
N27 PO[X]=(10,2.5) PO[Y]=(2.3)                                  ; No PL programmed; PL=1 applies
N30 G1 X… Y… Z.                                                 ; Polynomial interpolation off
…
```

Example: New polynomial syntax

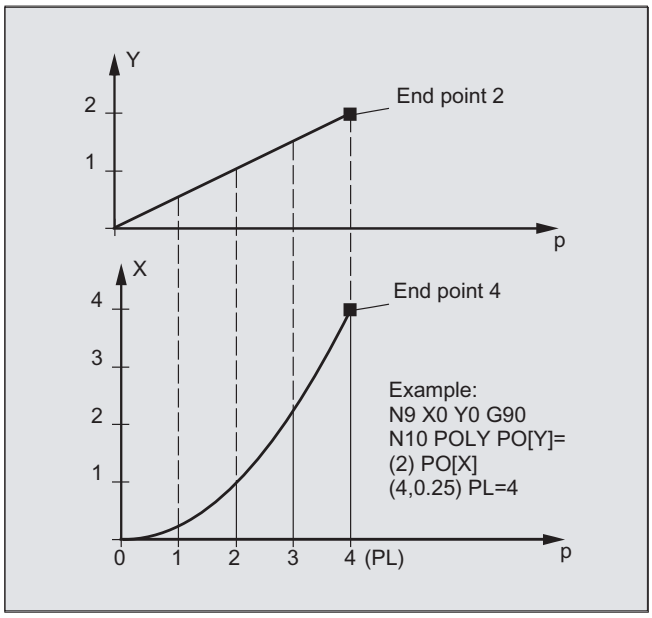
Polynomial syntax that is still valid	New polynomial syntax
`PO[axis identifier]=(.. , ..)`	`Axis identifier=PO(.. , ..)`
`PO[PHI]=(.. , ..)`	`PHI=PO(.. , ..)`
`PO[PSI]=(.. , ..)`	`PSI=PO(.. , ..)`
`PO[THT]=(.. , ..)`	`THT=PO(.. , ..)`
`PO[]=(.. , ..)`	`PO(.. , ..)`
`PO[variable]=IC(.. , ..)`	`variable=PO IC(.. , ..)`

Example: Curve in the X/Y plane

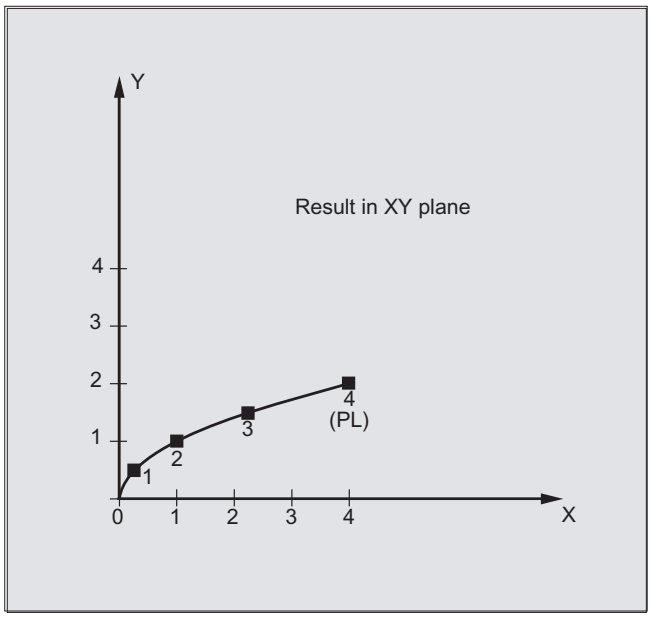
Programming

```
Program code
N9 X0 Y0 G90 F100
N10 POLY PO[Y]=(2) PO[X]=(4,0.25) PL=4
```

Shape of the curves X(p) and Y(p)



Shape of the curve in the XY plane



Description

The equation used to express the polynomial function is generally as follows:

$f(p)= a_0 + a_1p + a_2p^2 +. . . + a_np^n$

with: a_n: Constant coefficients
p: Parameter

In the controller, polynomials up to a maximum of the 5th degree can be programmed:

$f(p)= a_0 + a_1p + a_2p^2 + a_3p^3 + a_4p^4 + a_5p^5$

By assigning concrete values to these coefficients, it is possible to generate various curve shapes such as line, parabola and power functions.

A straight line is generated using $a_2 = a_3 = a_4 = a_5 = 0$:

$f(p) = a_0 + a_1p$

The following still applies:

$a_{0:}$ Axis position at the end of the preceding block

$p = PL$

$a_1 = (x_E - a_0 - a_2*p^2 - a_3*p^3)/p$

It is possible to program polynomials **without** the polynomial interpolation having been activated using the G command `POLY`. In this case, the programmed polynomials are not interpolated, but instead, all of the programmed end points of the axis are linearly approached (`G1`). The programmed polynomials are only moved as such after explicitly activating polynomial interpolation in the part program (`POLY`).

Special feature: Denominator polynomial

Command `PO[]=(…)` can be used to program a common denominator polynomial for the geometry axes (without specifying an axis name), i.e. the motion of the geometry axes is then interpolated as the quotient of two polynomials.

With this programming option, it is possible to represent shapes such as conics (circle, ellipse, parabola, hyperbola) exactly.

Example:

```
Program code                                  Comment
POLY G90 X10 Y0 F100                          ;   Geometry axes traverse linearly to
                                                  position X10 Y0.
PO[X]=(0,-10) PO[Y]=(10) PO[]=(2,1)           ;   Geometry axes traverse along the
                                                  quadrant to X0 Y10.
```

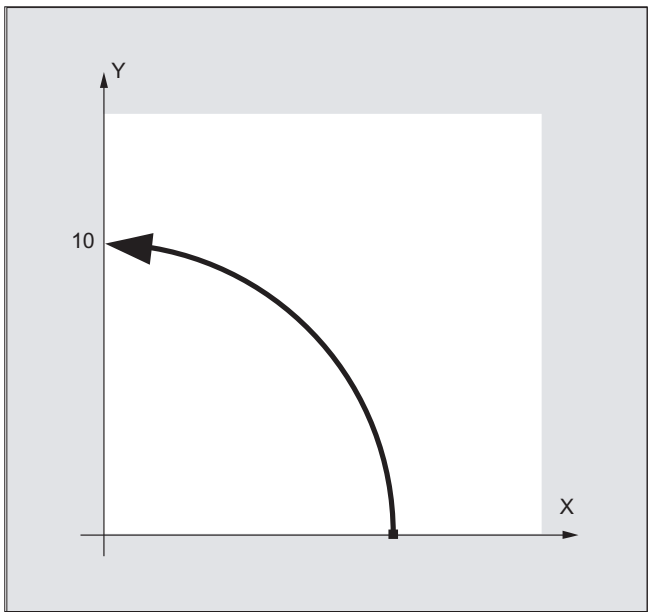
The constant coefficient (a_0) of the denominator polynomial is always assumed to be 1. The programmed end point is independent of `G90` / `G91`.

X(p) and Y(p) are calculated as follows from the programmed values:

$X(p) = (10 - 10 * p^2) / (1 + p^2)$
$Y(p) = 20 * p / (1 + p^2)$
with $0 \leq p \leq 1$

As a result of the programmed start points, end points, coefficient a_2 and PL=1, the intermediate results are as follows:

Numerator (X) = $10 + 0 * p - 10 * p^2$
Numerator (Y) = $0 + 20 * p + 0 * p^2$
Denominator = $1 + p^2$



If polynomial interpolation is active and a denominator polynomial is programmed with zeros within the interval `[0,PL]`, this is rejected and an alarm is output. Denominator polynomials have no effect on the motion of special axes.

Note

Tool radius compensation can be activated with `G41`, `G42` in conjunction with polynomial interpolation and can be applied in the same way as in linear or circular interpolation modes.

4.6 Settable path reference (SPATH, UPATH)

Function

During polynomial interpolation, the user may require two different relationships between the velocity determining FGROUP axes and the other path axes: The latter should either be controlled, synchronized to the path S or synchronized to the curve parameter U of the FGROUP axes.

Both types of path interpolation are used in different applications and can be set/switched over using the two modal language commands SPATH and UPATH contained in the 45th G code group.

Syntax

```
SPATH
UPATH
```

Meaning

SPATH:	Path reference for FGROUP axes is arc length
UPATH:	Path reference for FGROUP axes is curve parameter

Note

UPATH and SPATH also define the interrelationship of the F word polynomial (FPOLY, FCUB, FLIN) with path motion.

Supplementary conditions

The path reference set is of no importance:

- For linear and circular interpolation
- In thread blocks
- If all path axes are contained in FGROUP.

Examples

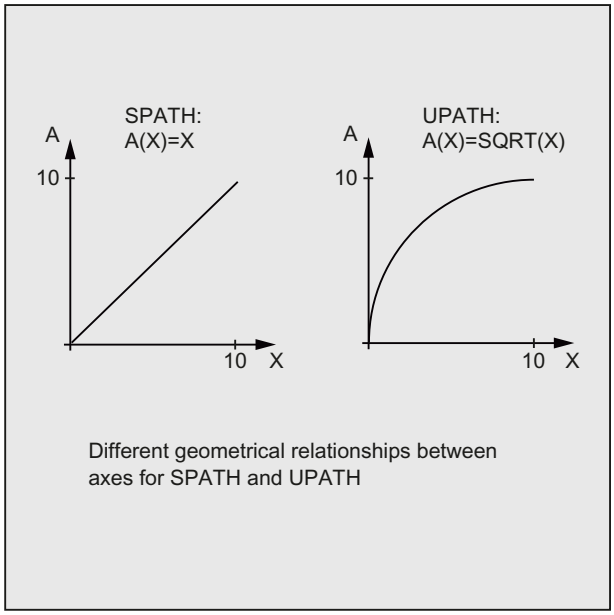
Example 1:

The following example shows a square with 20 mm side lengths and corners rounded-off with G643. The maximum deviations from the precise contour are defined for each axis using the axis-specific machine data MD33100 $MA_COMPRESS_POS_TOL[<n>].

```
Program code                    Comment
N10 G1 X… Y… Z… F500
N20 G643                        ; Block-internal corner rounding with G643
N30 XO Y0
N40 X20 Y0                      ; Edge length (mm) for the axes
N50 X20 Y20
N60 X0 Y20
N70 X0 Y0
N100 M30
```

Example 2:

The following example shows the difference between both types of motion control. Both times the default setting FGROUP(X,Y,Z) is active.



Different geometrical relationships between axes for SPATH and UPATH

```
Program code
N10 G1 X0 A0 F1000 SPATH
N20 POLY PO[X]=(10,10) A10
```

or

```
Program code
N10 G1 X0 F1000 UPATH
N20 POLY PO[X]=(10,10) A10
```

In block N20, path S of the FGROUP axes is dependent on the square of curve parameter U. Therefore, different positions are obtained for the synchronous axis A along path X, according to whether SPATH or UPATH is active.

Further information

During polynomial interpolation - and therefore this always involves polynomial interpolation in a strict sense (POLY), all spline interpolation types (ASPLINE, BSPLINE, CSPLINE) and linear interpolation with compressor function (COMPON, COMPCURV) - the positions of all path axes i are specified by the polynomial pi(U). Curve parameter U moves from 0 to 1 within an NC block, therefore it is standardized.

The axes to which the programmed path feed is to relate can be selected from the path axes by means of language command FGROUP. However, during polynomial interpolation, an interpolation with constant velocity on path S of these axes usually means a non constant change of curve parameter U.

Control behavior for reset and machine/option data

The G code, defined by MD20150 $MC_GCODE_RESET_VALUES[44] (45th G code group) is effective after a reset. In order to maintain compatibility with existing installations, SPATH is set as default value.

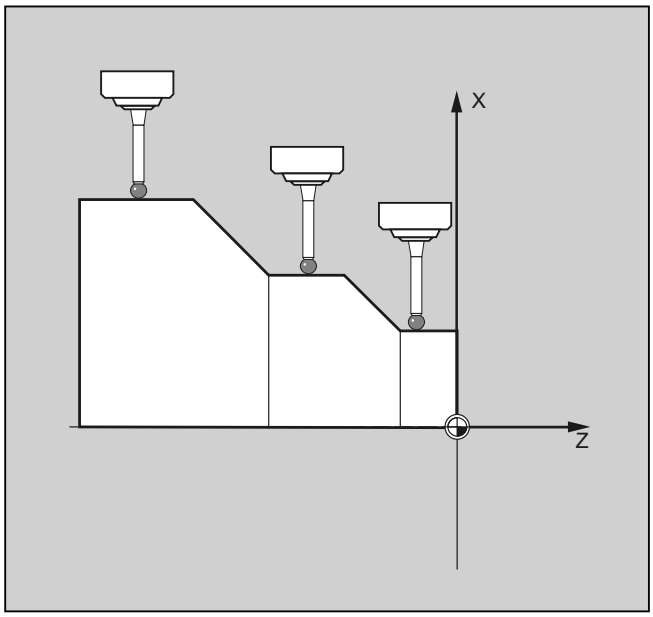
The initial state for the type of smoothing is defined with MD20150 $MC_GCODE_RESET_VALUES[9] (10th G code group).

The axis-specific machine data MD33100 $MA_COMPRESS_POS_TOL[<n>] has an extended significance: It contains the tolerances for the compressor function and for smoothing with G642.

4.7 Measuring with touch-trigger probe (MEAS, MEAW)

Function

The "Measure with touch-trigger probe" is used to approach actual positions on the workpiece. On the probe's switching edge, the positions for all axes programmed in the measurement block are measured and written to the appropriate memory cell for each axis.



The following two fixed addresses are available for programming the function:

- `MEAS`

  `MEAS` is used to delete the distance-to-go between the actual and setpoint positions.

- `MEAW`

  `MEAW` is used in the case of measuring tasks where the programmed position always needs to be approached.

`MEAS` and `MEAW` are non-modal; they are programmed together with motion operations. The feedrate and interpolation type (G0, G1, etc.) as well as the number of axes must be adapted for the respective measuring task.

Syntax

```
MEAS=<TE> G... X... Y... Z...
MEAW=<TE> G... X... Y... Z...
```

Meaning

`MEAS`:	Command: Measurement **with** delete distance-to-go Effective: Non-modal
`MEAW`:	Command: Measurement **without** delete distance-to-go Effective: Non-modal
`<TE>`:	Trigger event to initiate measurement Type: INT Range of values: -2, -1, 1, 2 Meaning: (+)1 Rising edge of probe 1 (measuring input 1) -1 Falling edge of probe 1 (measuring input 1) (+)2 Rising edge of probe 2 (measuring input 2) -2 Falling edge of probe 2 (measuring input 2) **Note:** There are up to a maximum of 2 probes (dependent on configuration level).
`G...`:	Type of interpolation, e.g. `G0`, `G1`, `G2` or `G3`
`X... Y... Z...` :	End points in Cartesian coordinates

Example

Program code	Comment
`N10 MEAS=1 G1 F1000 X100 Y730 Z40`	`; Measurement block with probe at first measuring input and linear interpolation. A preprocessing stop is automatically generated.`
`...`	

Further information

Measuring task status

If an evaluation of whether or not the probe has been triggered is required in the program, status variable $AC_MEA[<n>] (<n> = number of the measuring probe) can be checked:

Value	Meaning
0	Measuring task not completed.
1	Measuring task completed successfully (the probe has been triggered).

Note

If the program is deflected in the program, the variable is set to 1. At the start of a measurement block, the variable is automatically set to the initial state of the probe.

Reading measured values

The positions of all traversing path and positioning axes of the block are acquired (maximum number of axes depending on the control configuration). In the case of `MEAS`, the motion is decelerated in a defined fashion following the triggering of the probe.

Note

If a geometry axis is programmed in a measuring block, the measured values are stored for all current geometry axes.

If an axis participating in a transformation is programmed in a measurement block, the measured values for all axes participating in this transformation are recorded.

Reading measurement results

The measurement results for the axes measured with probes can be read via the following system variables:

- $AA_MM[<axis>]

  Measurement results in the machine coordinate system

- $AA_MW[<axis>]

  Measurement results in the workpiece coordinate system

No internal preprocessing stop is generated when these variables are read.

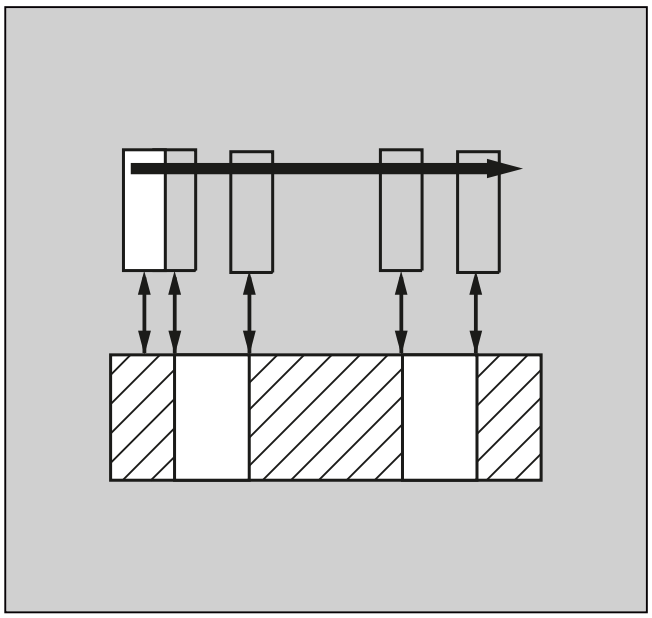
Note

A preprocessing stop must be programmed with `STOPRE` at the appropriate position in the program. The system will otherwise read false values.

4.8 Axial measurement (MEASA, MEAWA, MEAC) (option)

Function

Several probes and several measuring systems can be used for the axial measuring.



The keywords MEASA, MEAWE and MEAC are available for programming the function.

With MEASA or MEAWA for the programmed axis, up to four measured values are acquired for each measurement and are then saved in system variables in accordance with the trigger event.

Measuring operations can be executed with MEAC. In this case, the measurement results are stored in FIFO variables.

Syntax

```
MEASA[<axis>]=(<mode>,<TE1>,...,<TE4>)
MEAWA[<axis>]=(<mode>,<TE1>,...,<TE4>)
MEAC[<axis>]=(<mode>,<measurement memory>,<TE1>,...,<TE4>)
```

Note

MEASA and MEAWA are non-modal; they can be programmed together in one block. However, if MEASA/MEAWA is programmed together with MEAS/MEAW in the same block, an error message is output.

Meaning

`MEASA`: Keyword: Axial measurement with delete distance-to-go
Effective: Non-modal

`MEAWA`: Keyword: Axial measurement without delete distance-to-go
Effective: Non-modal

`MEAC`: Keyword: Continuous axial measurement without delete distance-to-go
Effective: Non-modal

`<axis>`: Name of channel axis used for measurement

`<mode>`: Two-digit number indicating the operating mode (measuring mode and measuring system)

Units decade (measuring mode):

0 Cancel measuring task.

1 Up to four different trigger events that can be activated at the same time.

2 Up to four different trigger events that can be activated in succession.

3 Up to four different trigger events that can be activated in succession, but with no monitoring of trigger event 1 at the start (alarms 21700/21703 are suppressed).

Note:
This mode is not supported by `MEAC`.

Tens decade (measuring system):

0 (or no data)	active measuring system
1	Measuring system 1
2	Measuring system 2
3	Both measuring systems

`<TE>`: Trigger event to initiate measurement

Type: INT

Range of values: -2, -1, 1, 2

Meaning:

(+)1	Rising edge of probe 1
-1	Falling edge of probe 1
(+)2	Rising edge of probe 2
-2	Falling edge of probe 2

`<measurement memory>`: Number of FIFO (circulating storage)

Examples

Example 1: Axial measurement with delete distance-to-go in mode 1 (evaluation in chronological sequence)

a) with 1 measuring system

```
Program code                                    Comment
...
N100 MEASA[X]=(1,1,-1) G01 X100 F100            ; Measuring in mode 1 with active
                                                  measuring system. Wait for
                                                  measuring signal with
                                                  rising/falling edge from probe 1
                                                  for travel path to X=100.
N110 STOPRE                                     ; Preprocessing stop
N120 IF $AC_MEA[1]==FALSE GOTOF END             ; Check that the measurement was
                                                  successful.
N130 R10=$AA_MM1[X]                             ; Save measured value acquired at
                                                  the first programmed trigger event
                                                  (rising edge).
N140 R11=$AA_MM2[X]                             ; Save measured value acquired at
                                                  the second programmed trigger
                                                  event (falling edge).
N150 END:
```

b) with 2 measuring systems

```
Program code                                    Comment
...
N200 MEASA[X]=(31,1,-1) G01 X100 F100           ; Measuring in mode 1 with both
                                                  measuring systems. Wait for
                                                  measuring signal with
                                                  rising/falling edge from probe 1
                                                  for travel path to X=100.
N210 STOPRE                                     ; Preprocessing stop
N220 IF $AC_MEA[1]==FALSE GOTOF END             ; Check that the measurement was
                                                  successful.
N230 R10=$AA_MM1[X]                             ; Save measured value of measuring
                                                  system 1 at rising edge.
N240 R11=$AA_MM2[X]                             ; Save measured value of measuring
                                                  system 2 at rising edge.
N250 R12=$AA_MM3[X]                             ; Save measured value of measuring
                                                  system 1 at falling edge.
N260 R13=$AA_MM4[X]                             ; Save measured value of measuring
                                                  system 2 at falling edge.
N270 END:
```

Example 2: Axial measurement with delete distance-to-go in mode 2 (evaluation in programmed sequence)

```
Program code                                    Comment
...
N100 MEASA[X]=(2,1,-1,2,-2) G01 X100 F100       ; Measuring in mode 2 with active measuring
                                                  system. Wait for measuring signal in the
                                                  sequence rising edge probe 1, falling edge
                                                  probe 1, rising edge probe 2, falling edge
                                                  probe 2 while traversing path to X=100.
N110 STOPRE                                     ; Preprocessing stop
N120 IF $AC_MEA[1]==FALSE GOTOF PROBE2          ; Check that the measurement with probe 1 is
                                                  successful.
N130 R10=$AA_MM1[X]                             ; Save measured value acquired at the first
                                                  programmed trigger event (rising edge of probe
                                                  1).
N140 R11=$AA_MM2[X]                             ; Save measured value acquired at the second
                                                  programmed trigger event (rising edge of probe
                                                  1).
N150 PROBE2:
N160 IF $AC_MEA[2]==FALSE GOTOF END             ; Check that the measurement with probe 2 is
                                                  successful.
N170 R12=$AA_MM3[X]                             ; Save measured value acquired at the third
                                                  programmed trigger event (rising edge of probe
                                                  2).
N180 R13=$AA_MM4[X]                             ; Save measured value acquired at the fourth
                                                  programmed trigger event (rising edge of probe
                                                  2).
N190 END:
```

Example 3: Continuous axial measurement in mode 1 (evaluation in chronological sequence)

a) Measurement of up to 100 measured values

```
Program code                                    Comment
...
N110 DEF REAL MEASVALUE[100]
N120 DEF INT loop=0
N130 MEAC[X]=(1,1,-1) G01 X1000 F100            ; Measurement in mode with active measuring system,
                                                  save measured values under $AC_FIFO1, wait for
                                                  measuring signal with falling edge of probe 1 while
                                                  traversing path to X=1000.
N135 STOPRE
N140 MEAC[X]=(0)                                ; Terminate measurement when axis position is reached.
N150 R1=$AC_FIFO1[4]                            ; Save number of accumulated measured values in
                                                  parameter R1.
N160 FOR loop=0 TO R1-1
```

```
Program code                                    Comment
N170 MEASURED VALUE[loop]=$AC_FIFO1[0]          ; Read-out measured values from $AC_FIFO1 and save.
N180 ENDFOR
```

b) Measurement with delete distance-to-go after 10 measured values

```
Program code                                                    Comment
...
N10 WHEN $AC_FIFO1[4]>=10 DO MEAC[x]=(0) DELDTG(x)              ; Delete distance-to-
                                                                  go.
N20 MEAC[x]=(1,1,1,-1) G01 X100 F500
N30 MEAC [X]=(0)
N40 R1 = $AC_FIFO1[4]                                           ; Number of measured
                                                                  values.
...
```

c) Measurement of a falling/rising tooth flank with two probes

```
Program code                                    Comment
...
N110 DEF REAL MEASVALUE[16]
N120 DEF INT loop=0
N130 MEAC[X]=(1,1,-1,2) G01 X100 F100           ; Measurement in mode 1 with active
                                                  measuring system, save measured
                                                  values under $AC_FIFO1, wait for
                                                  measuring signal in the sequence
                                                  falling edge of probe 1, rising edge
                                                  of probe 2 while traversing the path
                                                  to X=100.
N140 STOPRE                                     ; Preprocessing stop
N150 MEAC[X]=(0)                                ; Terminate measurement when axis
                                                  position is reached.
N160 R1=$AC_FIFO1[4]                            ; Save number of accumulated measured
                                                  values in parameter R1.
N170 FOR loop=0 TO R1-1
N180 MEASURED VALUE[loop]=$AC_FIFO1[0]          ; Read-out measured values from
                                                  $AC_FIFO1 and save.
N190 ENDFOR
```

Further information

Measurement job

A measuring task can be programmed in the part program or from a synchronized action (see Section "Synchronized actions (Page 553)"). Please note that only one measuring job can be active at any given time for each axis.

Note

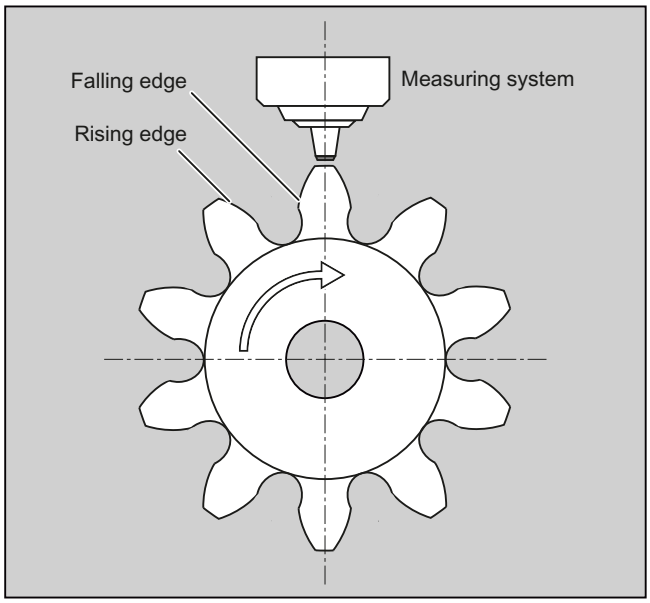
The feed must be adjusted to suit the measuring task in hand.

In the case of MEASA and MEAWA, the correctness of results can be only guaranteed for feedrates at which no more than 1 trigger event of the same type and no more than 4 trigger events of different types occur in each position control cycle.

In the case of continuous measurement with MEAC, the ratio between interpolation cycle and position control cycle must not exceed 8:1.

Trigger event

A trigger event comprises the number of the probe and the trigger criterion (rising or falling edge) of the measuring signal.



Up to 4 trigger events of the addressed probe can be processed for each measurement; in other words, up to 2 probes with 2 measuring signal edges each. The processing sequence and the maximum number of trigger events depend on the selected mode.

Note

The following applies for measuring mode 1: The same trigger event may only be programmed once in one measuring task.

With MEAC, the number of measured values per position control cycle can be increased to eight rising edges and to eight falling edge for each probe. This enables higher feedrates and speeds to be implemented.

References:
Function Manual, Extended Functions; Measurements (M5), Section: Axial measurement

Operating mode

The first digit (tens decade) of the operating mode selects the required measuring system. If only one measuring system is installed, but a second programmed, the installed system is automatically selected.

The second digit (units decade) selects the required measuring mode. The measuring process is thus adapted to the options supported by the relevant control:

- **Mode 1**

  Trigger events are evaluated in the chronological sequence in which they occur. When this mode is selected, only one trigger event can be programmed for six-axis modules. If more than one trigger event is specified, the mode selection is switched automatically to mode 2 (without message).

- **Mode 2**

  Trigger events are evaluated in the programmed sequence.

- **Mode 3**

  Trigger events are evaluated in the programmed sequence but there is no monitoring of trigger event 1 at START.

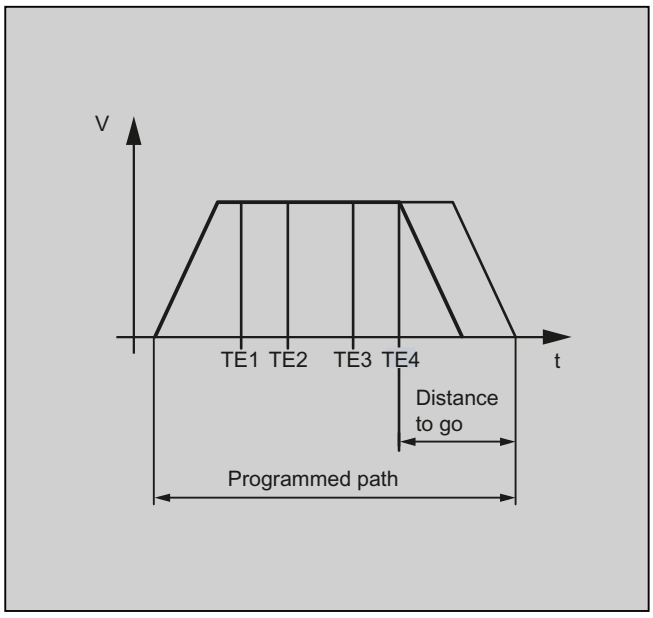
Note

No more than two trigger events can be programmed if two measuring systems are in use.

Measurement with and without delete distance-to-go

When command `MEASA` is programmed, the distance-to-go is not deleted until all required measured values have been recorded.

The `MEAWA` function is used in the case of special measuring tasks where a programmed position always needs to be approached.



Note

MEASA cannot be programmed in synchronized actions. As an alternative, MEAWA plus delete distance-to-go can be programmed as a synchronized action.

If the measuring task with MEAWA is started from synchronized actions, the measured values will only be available in the machine coordinate system.

Measurement results for MEASA, MEAWA

The results of measurements are available under the following system variables:

- In the machine coordinate system:

$AA_MM1[<axis>]	Measured value of programmed measuring system on trigger event 1
...	...
$AA_MM4[<axis>]	Measured value of programmed measuring system on trigger event 4

- In the workpiece coordinate system:

$AA_WM1[<axis>]	Measured value of programmed measuring system on trigger event 1
...	...
$AA_WM4[<axis>]	Measured value of programmed measuring system on trigger event 4

Note

No internal preprocessing stop is generated when these variables are read. A preprocessing stop must be programmed with STOPRE at the appropriate position in the program. False values will otherwise be read in.

Geometry axes/Transformations

If axial measurement is to be started for a geometry axis, the same measuring job must be programmed explicitly for all remaining geometry axes. The same applies to axes involved in a transformation.

Examples:

```
N10 MEASA[Z]=(1,1) MEASA[Y]=(1,1) MEASA[X]=(1,1) G0 Z100
```

or

```
N10 MEASA[Z]=(1,1) POS[Z]=100
```

Measurement job with two measuring systems

If a measuring job is executed by two measuring systems, each of the two possible trigger events of both measuring systems of the relevant axis is acquired. The assignment of the reserved variables is therefore preset:

$AA_MM1[<axis>]	or	$AA_MW1[<axis>]	Measured value from measuring system 1 on trigger event 1
$AA_MM2[<axis>]	or	$AA_MW2[<axis>]	Measured value from measuring system 2 on trigger event 1

`$AA_MM3[<axis>]`	or	`$AA_MW3[<axis>]`	Measured value from measuring system 1 on trigger event 2
`$AA_MM4[<axis>]`	or	`$AA_MW4[<axis>]`	Measured value from measuring system 2 on trigger event 2

System variables

The probe status is available in the following system variables:

$A_PROBE[<n>]

Value	Meaning
1	Probe deflected
0	Probe not deflected

The probe limitation is available in the following system variables:

$A_PROBE_LIMITED[<n>]

Value	Meaning
1	Probe limitation active
0	Probe limitation inactive

<n> = probe

Reference:
Parameter Manual, System Variables

Measuring job status for MEASA, MEAWA

If an evaluation is required in the program, the measuring task status can be queried via $AC_MEA[<n>], where <n> = number of the probe. Once all the trigger events of probe <n> that are programmed in a block have occurred, this variable returns a value of "1". Otherwise, its value is 0.

Note

If measurement is started from synchronized actions, $AC_MEA is no longer updated. In this case, the new PLC interface signal DB31, … DBX62.3 or the equivalent variable $AA_MEAACT[<axis>] must be queried.

Meaning:

$AA_MEAACT==1: Measurement active

$AA_MEAACT==0: Measurement not active

Continuous measurement (MEAC)

The measured values for MEAC are available in the machine coordinate system and stored in the programmed FIFO[n] memory (circular buffer). If two probes are configured for the measurement, the measured values of the second probe are stored separately in the FIFO[n+1] memory configured especially for this purpose (defined in machine data).

The FIFO memory is a circular buffer in which measured values are written to $AC_FIFO variables according to the circular principle, see Section "Synchronized actions (Page 553)".

Note

FIFO contents can be read only once from the circulating storage. If this measured data is to be used several times, it must be buffered in the user data.

If the number of measured values for the FIFO memory exceeds the maximum value defined in machine data, the measurement is automatically terminated.

An endless measuring process can be implemented by reading out measured values cyclically. In this case, data must be read out at the same frequency as new measured values are read in.

References:

- Function Manual, Synchronized Actions; Detailed Description,
  Section: Parameters ($AC_FIFO)
- Function Manual, Extended Functions; Measurements (M5), Section: Axial measurement

Protection against programming errors

The following programming errors are detected and indicated appropriately:

- MEASA/MEAWA programmed with MEAS/MEAW in the same block

  Example:

  ```
  N01 MEAS=1 MEASA[X]=(1,1) G01 F100 POS[X]=100
  ```

- MEASA/MEAWA with number of parameters <2 or >5

  Example:

  ```
  N01 MEAWA[X]=(1) G01 F100 POS[X]=100
  ```

- MEASA/MEAWA with trigger event not equal to 1/ -1/ 2/ -2

  Example:

  ```
  N01 MEASA[B]=(1,1,3) B100
  ```

- MEASA/MEAWA with invalid mode

  Example:

  ```
  N01 MEAWA[B]=(4,1) B100
  ```

- MEASA/MEAWA with trigger event programmed twice

  Example:

  ```
  N01 MEASA[B]=(1,1,-1,2,-1) B100
  ```

- MEASA/MEAWA and missing geometry axis

  Example:

  ```
  N01 MEASA[X]=(1,1) MEASA[Y]=(1,1) G01 X50 Y50 Z50 F100 ;GEO axis X/Y/Z
  ```

- Inconsistent measuring task with geometry axes

  Example:

  ```
  N01 MEASA[X]=(1,1) MEASA[Y]=(1,1) MEASA[Z]=(1,1,2) G01 X50 Y50 Z50 F100
  ```

4.9 Special functions for OEM users (OMA1 ... OMA5, OEMIPO1, OEMIPO2, G810 ... G829)

OEM addresses

The meaning of OEM addresses is determined by the OEM user. Their functionality is incorporated by means of compile cycles. Five OEM addresses are reserved (OMA1 ... OMA5). The address identifiers are settable. OEM addresses can be programmed in any block.

Reserved G function calls

The following G function calls are reserved for OEM users:

- OEMIPO1, OEMIPO2 (from G function group 1)
- G810 ... G819 (G function group 31)
- G820 ... G829 (G function group 32)

Their functionality is incorporated by means of compile cycles.

Functions and subprograms

OEM users can also set up predefined functions and subprograms with parameter transfer.

Note

Workpiece simulation

Up to SW 4.4, no compile cycles are supported, as ofSW 4.4 only selected compile cycles (CC) are supported for the workpiece simulation.

Language commands in the part program of compile cycles that are not supported (OMA1 ... OMA5, OEMIPO1/2, G810 ... G829, own procedures and functions) - therefore result in an alarm message and cancellation of the simulation without any individual handling.

Solution: Individually handle the missing CC-specific language elements in the part program ($P_SIM query).
Example:

```
N1 G01 X200 F500

IF (1==$P_SIM)

N5 X300 ;not active for CC simulation

ELSE

N5 X300 OMA1=10

ENDIF
```

4.10 Feedrate reduction with corner deceleration (FENDNORM, G62, G621)

Function

With automatic corner deceleration the feed rate is reduced according to a bell curve before reaching the corner. It is also possible to parameterize the extent of the tool behavior relevant to machining via setting data. These are:

- Start and end of feed rate reduction
- Override with which the feed rate is reduced
- Detection of a relevant corner

Relevant corners are those whose inside angle is less than the corner parameterized in the setting data.

Default value FENDNORM deactivates the function of the automatic corner override.

References:
/FBFA/ "Function Description ISO Dialects"

Syntax

```
FENDNORM
G62 G41
G621
```

Meaning

FENDNORM	Automatic corner deceleration OFF
G62	Corner deceleration at inside corners when tool radius offset is active
G621	Corner deceleration at all corners when tool radius offset is active

G62 only applies to inside corners with

- active tool radius offset G41, G42 and
- active continuous-path mode G64, G641

The corner is approached at a reduced feed rate resulting from:

F * (override for feed rate reduction) * feed rate override

The maximum possible feed rate reduction is attained at the precise point where the tool is to change directions at the corner, with reference to the center path.

G621 applies analogously with G62 at each corner of the axes defined by FGROUP.

4.11 Programmable end of motion criteria (FINEA, COARSEA, IPOENDA, IPOBRKA, ADISPOSA)

Function

Similar to the block change criterion for path interpolation (G601, G602, and G603) it is also possible to program the end-of-motion criterion for singleaxis interpolation in a part program or in synchronized actions for command/PLC axes.

The end-of-motion criterion set will affect how quickly or slowly part program blocks and technology cycle blocks with singleaxis movements are completed. The same applies for PLC via FC15/16/18.

Syntax

```
FINEA[<axis>]
COARSEA[<axis>]
IPOENDA[<axis>]
IPOBRKA(<axis>[,<instant in time>])
ADISPOSA[<axis>]=(<mode>,<window size>)
```

Meaning

FINEA:	End-of-motion criterion: "Exact stop fine" Effective: Modal
COARSEA:	End-of-motion criterion: "Exact stop coarse" Effective: Modal
IPOENDA:	End-of-motion criterion:"interpolator stop" Effective: Modal
IPOBRKA:	Block change criterion: Braking ramp Effective: Modal
ADISPOSA:	Tolerance window for end-of-motion criterion Effective: Modal
<axis>:	Channel axis name (X, Y, ...)
<instant in time>:	Time of the block change, referred to the braking ramp as a %: • 100% = start of the braking ramp • 0% = end of the braking ramp, the same significance as IPOENDA Type: REAL
<mode>:	Reference of the tolerance window Range of values: 0 Tolerance window not active 1 Tolerance window with respect to set position 2 Tolerance window with respect to actual position Type: INT
<window size>:	Size of the tolerance window Type: REAL

Examples

Example 1: End-of-motion criterion: "Interpolator stop"

Program code

```
; traverse positioning axis X to 100, velocity 200 m/min, acceleration 90%,
; end-of-motion criterion: Interpolator stop
N110 G01 POS[X]=100 FA[X]=200 ACC[X]=90 IPOENDA[X]

; Synchronized action:
; ALWAYS IF: Input 1 is set
; THEN traverse positioning axis X to 50, velocity 200 m/min, acceleration 140%,
; end-of-motion criterion: Interpolator stop
N120 EVERY $A_IN[1] DO POS[X]=50 FA[X]=200 ACC[X]=140 IPOENDA[X]
```

Example 2: Block change criterion: "Braking ramp"

```
Program code                Comment
                            ; Default setting is effective
N40 POS[X]=100              ; Positioning motion from X to position 100
                            ; Block change criterion: Exact stop fine
N20 IPOBRKA(X,100)          ; Block change criterion: "Braking ramp",
                            ; 100% = start of the braking ramp
N30 POS[X]=200              ; The block is changed as soon as the X axis starts to brake
N40 POS[X]=250              ; X axis no longer brakes at position 200 - but continues to traverse
                            ; to position 250.
                            ; As soon as the axis starts to brake, the block changes
N50 POS[X]=0                ; Axis X brakes and returns to position 0
                            ; The block change takes place at position 0 and "exact stop fine"
N60 X10 F100                ; Axis X traverses as path axis to position 10
```

Further information

System variable for end-of-motion criterion

The effective end-of-motion criterion can be read using the system variable $AA_MOTEND.

References: /LIS2sl/ List Manual, Book 2

Block-change criterion: "Braking ramp" (IPOBRKA)

If, when activating the block change criterion "brake ramp", a value is programmed for the optional block change instant in time, then this becomes effective for the next positioning motion and is written into the setting data synchronized to the main run. If no value is specified for the block change instant in time, then the actual value of the setting data is effective.

SD43600 $SA_IPOBRAKE_BLOCK_EXCHANGE

`IPOBRKA` is deactivated for the corresponding access when an axis end-of-motion criterion (`FINEA`, `COARSEA`, `IPOENDA`) is next programmed for the axis.

Additional block-change criterion: "Tolerance window" (ADISPOSA)

Using `ADISPOSA`, a tolerance window around the end of block (either as actual or setpoint position) can be defined as additional block change criterion. Then, two conditions must be fulfilled for the block change:

- Block-change criterion: "Braking ramp"
- Block-change criterion: "Tolerance window"

References

For further information about the block change criterion for positioning axes, see:

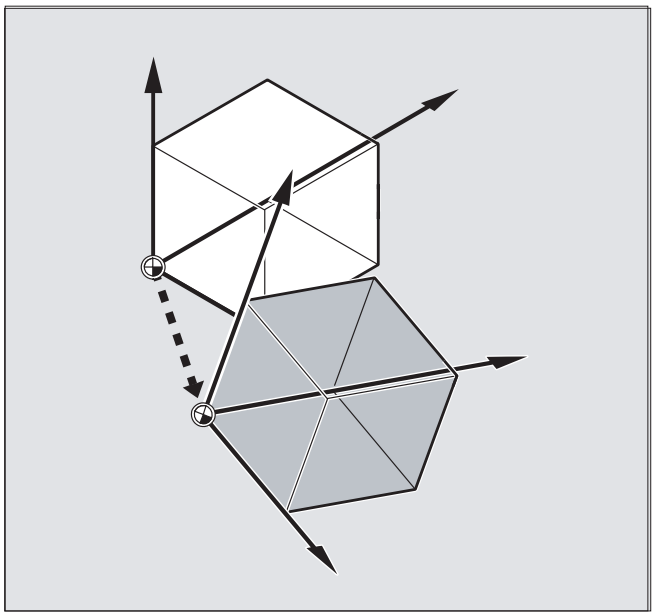
- Function Manual, Extended Functions; Positioning Axes (P2)
- Programming Manual, Fundamentals; Chapter "Feedrate control".

Coordinate transformations (frames) 5

5.1 Coordinate transformation via frame variables

Function

In addition to the programming options already described in the Programming Manual "Fundamentals", you can also define coordinate systems with predefined frame variables.



The following coordinate systems are defined:

MCS: Machine coordinate system

BCS: Basic coordinate system

BZS: Basic zero system

SZS: Settable zero system

WCS: Workpiece coordinate system

What is a predefined frame variable?

Predefined frame variables are keywords whose use and effect are already defined in the controller language and that can be processed in the NC program.

Possible frame variable:

- Basic frame (basic offset)
- Settable frames
- Programmable frame

Value assignments and reading the actual values

Frame variable/frame relationship

A coordinate transformation can be activated by assigning the value of a frame to a frame variable.

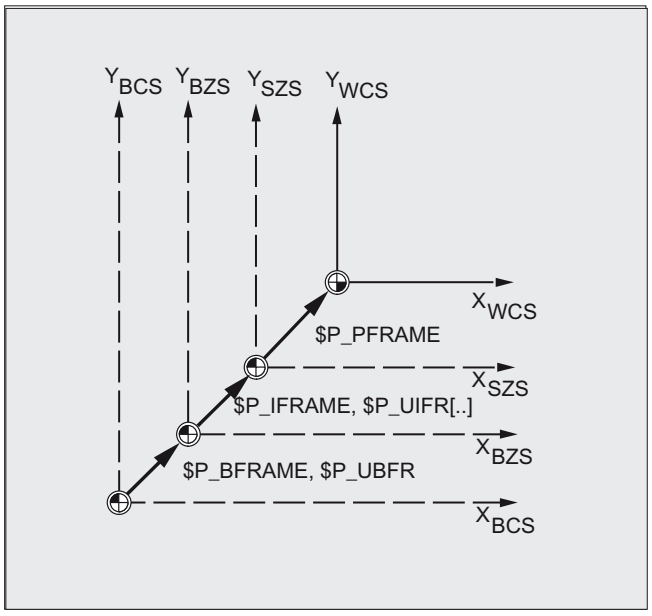
Example: `$P_PFRAME=CTRANS(X,10)`

Frame variable:

`$P_PFRAME` means: current programmable frame.

Frame:

`CTRANS(X,10)` means: programmable zero offset of X axis by 10 mm.



Reading the actual values

The current actual values of the coordinate system can be read out via predefined variables in the part program:

$AA_IM[axis]: Read actual value in MCS

$AA_IB[axis]: Read actual value in BCS

$AA_IBN[axis]: Read actual value in BZS

$AA_IEN[axis]: Read actual value in SZS

$AA_IW[axis]: Read actual value in WCS

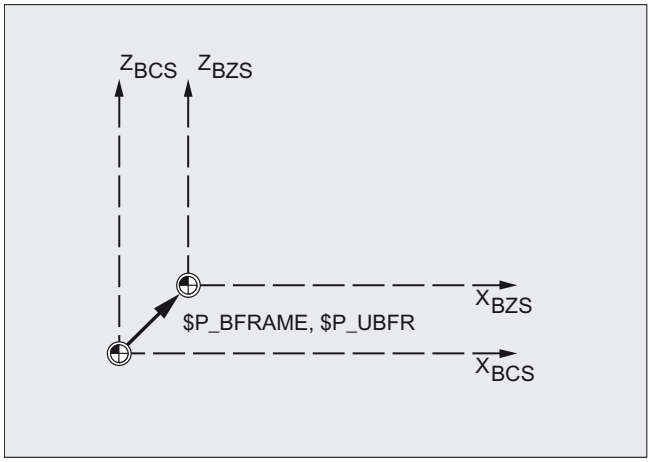
5.1.1 Predefined frame variable ($P_IFRAME, $P_BFRAME, $P_PFRAME, $P_ACTFRAME)

$P_BFRAME

Current basic frame variable that establishes the reference between the basic coordinate system (BCS) and the basic origin system (BOS).

For the basic frame described via $P_UBFR to be immediately active in the program, either

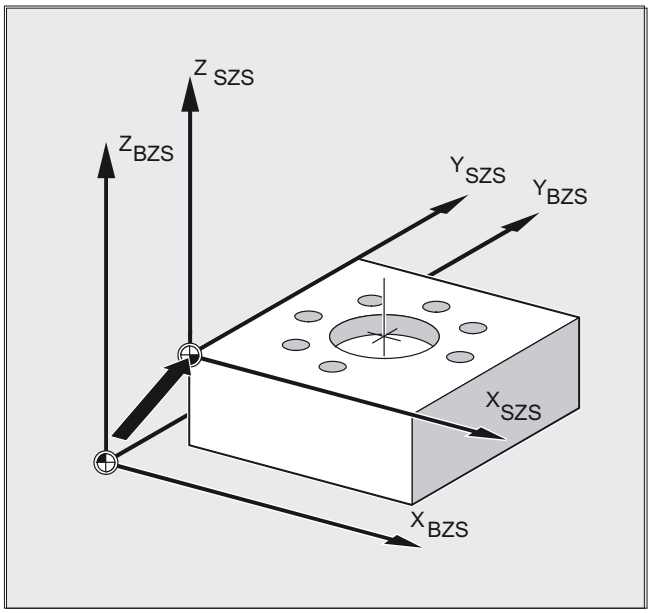
- You have to program a `G500`, `G54...G599`, or
- You have to describe `$P_BFRAME` with `$P_UBFR`



$P_IFRAME

Current, settable frame variable that establishes the reference between the basic origin system (BOS) and the settable zero system (SZS).

- `$P_IFRAME` corresponds to `$P_UIFR[$P_IFRNUM]`
- After `G54` is programmed, for example, `$P_IFRAME` contains the translation, rotation, scaling and mirroring defined by G54.

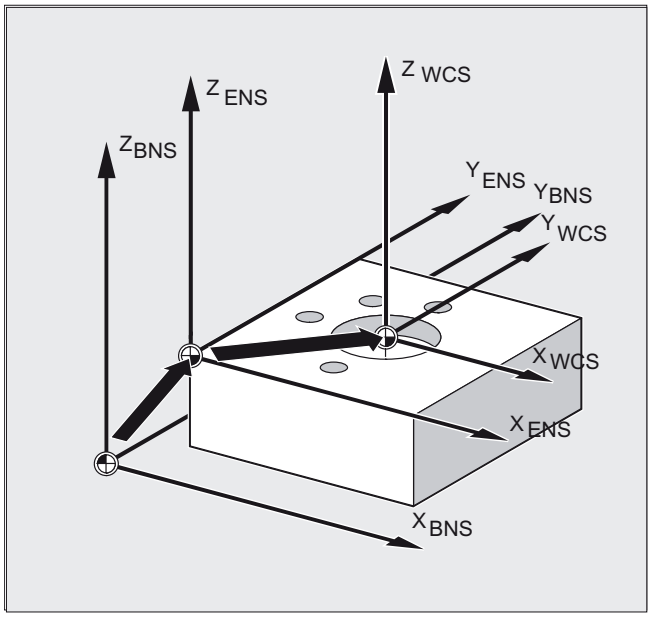


$P_PFRAME

Current, programmable frame variable that establishes the reference between the settable zero system (SZS) and the workpiece coordinate system (WCS).

`$P_PFRAME` contains the resulting frame, that results

- **From the programming** of `TRANS/ATRANS`, `ROT/AROT`, `SCALE/ASCALE`, `MIRROR/AMIRROR` or
- **From the assignment** of `CTRANS`, `CROT`, `CMIRROR`, `CSCALE` to the programmed FRAME



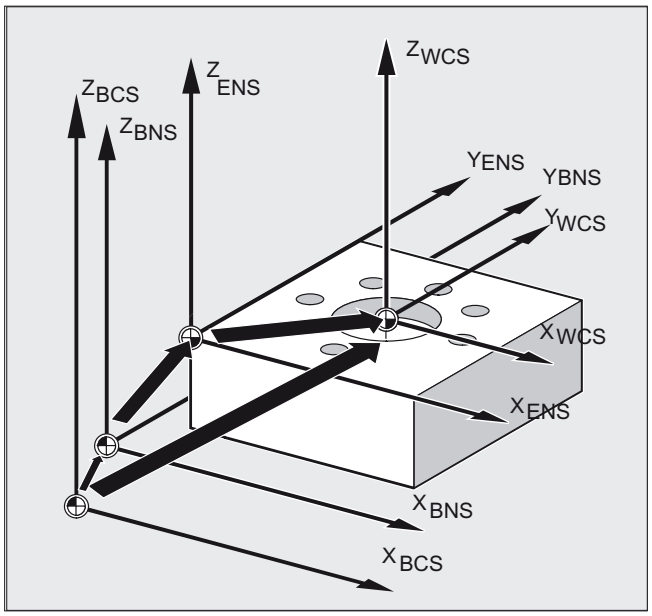
$P_ACTFRAME

Current, resulting complete frame that results from chaining

- The current basic frame variable `$P_BFRAME`,
- The currently settable frame variable `$P_IFRAME` with system frames and
- The currently programmable frame variable `$P_IFRAME` with system frames.

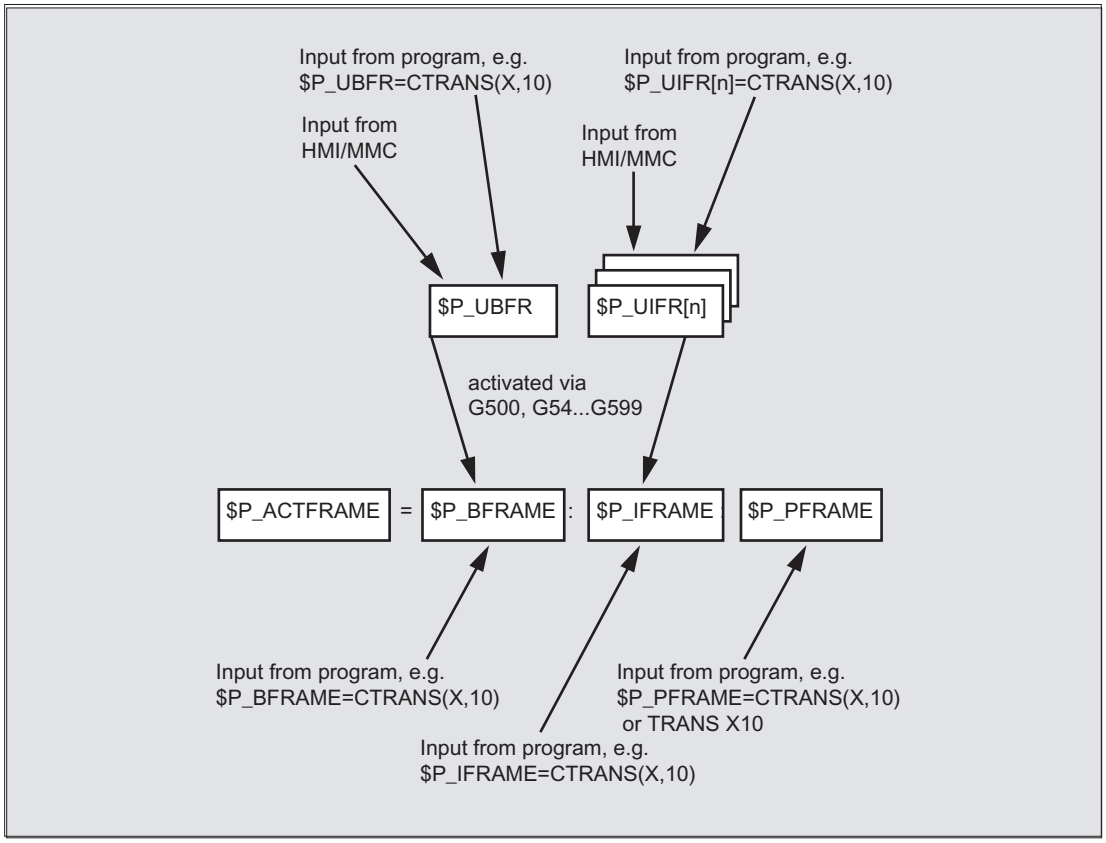
System frames, see Section "Frames that act in the channel"

`$P_ACTFRAME` describes the currently valid workpiece zero.



If `$P_IFRAME`, `$P_BFRAME` or `$P_PFRAME` are changed, `$P_ACTFRAME` is recalculated.

`$P_ACTFRAME` corresponds to `$P_BFRAME`:`$P_IFRAME`:`$P_PFRAME`



Basic frame and settable frame are effective after Reset if MD 20110 RESET_MODE_MASK is set as follows:

Bit0=1, bit14=1 --> `$P_UBFR` (basic frame) acts

Bit0=1, bit5=1 --> `$P_UIFR [$P_UIFRNUM]`(settable frame) acts

Predefined settable frames $P_UBFR

The basic frame is programmed with $P_UBFR, but it is not simultaneously active in the part program. The basic frame programmed with $P_UBFR is included in the calculation if

- Reset was activated and bits 0 and 14 are set in MD RESET_MODE_MASK and
- The statements `G500`,`G54...G599` were executed.

Predefined settable frames $P_UIFR[n]

The predefined frame variable $P_UIFR[n] can be used to read or write the settable zero offsets `G54` to `G599` from the part program.

These variables produce a one-dimensional array of type FRAME called `$P_UIFR[n]`.

Assignment to G commands

As standard, five settable frames `$P_UIFR[0]... $P_UIFR[4]` or five equivalent G commands – `G500` and `G54` to `G57`, can be saved using their address values.

Note

Frame variables must be programmed in a separate NC block in the NC program. **Exception:** Programming of a settable frame with `G54`, `G55`, `...`

`$P_IFRAME=$P_UIFR[0]` corresponds to `G500`

`$P_IFRAME=$P_UIFR[1]` corresponds to `G54`

`$P_IFRAME=$P_UIFR[2]` corresponds to `G55`

`$P_IFRAME=$P_UIFR[3]` corresponds to `G56`

`$P_IFRAME=$P_UIFR[4]` corresponds to `G57`

You can change the number of frames with machine data:

`$P_IFRAME=$P_UIFR[5]` corresponds to `G505`

`... ... ...`

`$P_IFRAME=$P_UIFR[99]` corresponds to `G599`

Note

This allows you to generate up to 100 coordinate systems which can be called up globally in different programs, for example, as zero point for various fixtures.

5.2 Frame variables / assigning values to frames

5.2.1 Assigning direct values (axis value, angle, scale)

Function

You can directly assign values to frames or frame variables in the NC program.

Syntax

```
$P_PFRAME=CTRANS (X, axis value, Y, axis value, Z, axis value, …)
$P_PFRAME=CROT (X, angle, Y, angle, Z, angle, …)
$P_UIFR[..]=CROT (X, angle, Y, angle, Z, angle, …)
$P_PFRAME=CSCALE (X, scale, Y, scale, Z, scale, …)
$P_PFRAME=CMIRROR (X, Y, Z)
```

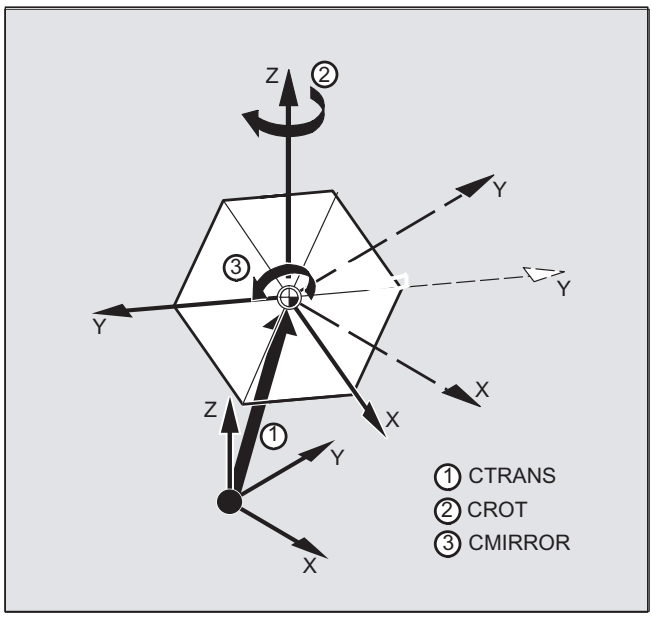
Programming $P_BFRAME is carried out analog to $P_PFRAME.

Meaning

`CTRANS`	Translation of specified axes
`CROT`	Rotation around specified axes
`CSCALE`	Scale change on specified axes
`CMIRROR`	Direction reversal on specified axis
`X Y Z`	Offset value in the direction of the specified geometry axis
`Axis value`	Assigning the axis value of the offset
`Angle`	Assigning the angle of rotation around the specified axes
`Scale`	Changing the scale

Example

Translation, rotation and mirroring are activated by value assignment to the current programmable frame.




```
N10 $P_PFRAME=CTRANS(X,10,Y,20,Z,5):CROT(Z,45):CMIRROR(Y)
```

Frame-red components are pre-assigned other values

With CROT, pre-assign all three UIFR components with values

Program code	Comment
`$P_UIFR[5] = CROT(X, 0, Y, 0, Z, 0)`	
`N100 $P_UIFR[5, y, rt]=0`	
`N100 $P_UIFR[5, x, rt]=0`	
`N100 $P_UIFR[5, z, rt]=0`	

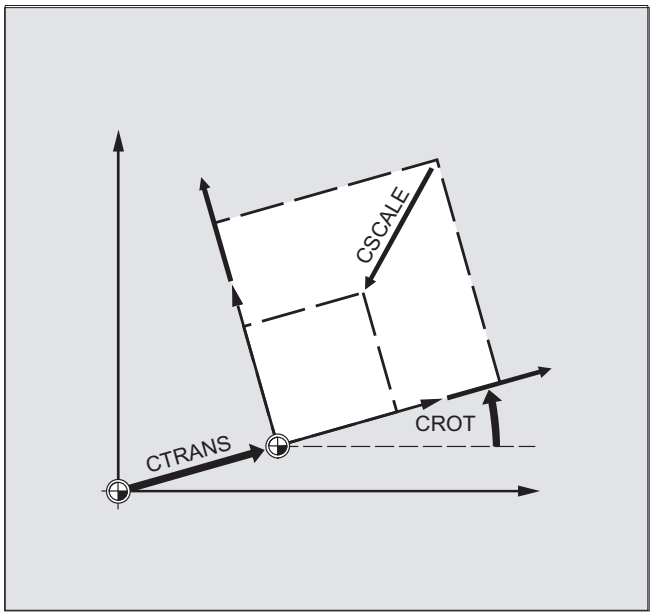
Description

You can program several arithmetic rules in succession.

Example:

```
$P_PFRAME=CTRANS(…):CROT(…):CSCALE…
```

Please note that the commands must be connected by the colon chain operator: (...):(...). This causes the commands firstly to be linked and secondly to be executed additively in the programmed sequence.



Note

The values programmed with the above commands are assigned to the frames and stored.

The values are not activated until they are assigned to the frame of an active frame variable `$P_BFRAME` or `$P_PFRAME` .

5.2.2 Reading and changing frame components (TR, FI, RT, SC, MI)

Function

This feature allows you to access **individual** data of a frame, e.g. a specific offset value or angle of rotation. You can modify these values or assign them to another variable.

Syntax

`R10=$P_UIFR[$P_UIFNUM,X,RT]`	Assign the angle of rotation RT around the X axis from the currently valid settable zero offset $P_UIFRNUM to the variable R10.
`R12=$P_UIFR[25,Z,TR]`	Assign the offset value TR in Z from the data record of set frame no. 25 to the variable R12.
`R15=$P_PFRAME[Y,TR]`	Assign the offset value TR in Y of the current programmable frame to the variable R15.
`$P_PFRAME[X,TR] = 25`	Modify the offset value TR in X of the current programmable frame. X25 applies immediately.

Meaning

`$P_UIFRNUM`	This command automatically establishes the reference to the currently valid settable zero offset.
`P_UIFR[n,…,…]`	Specify the frame number n to access the settable frame no. n.
	Specify the component to be read or modified:
`TR`	TR Translation
`FI`	FI Translation Fine
`RT`	RT Rotation
`SC`	SC Scale scale modification
`MI`	MI Mirroring
`X Y Z`	The corresponding axis X, Y, Z is also specified (see examples).

Value range for RT rotation

Rotation around 1st geometry axis: -180° to +180°
Rotation around 2nd geometry axis: -90° to +90°
Rotation around 3rd geometry axis: -180° to +180°

Description

Calling frame

By specifying the system variable $P_UIFRNUM you can access the current zero offset set with $P_UIFR or G54, G55, ...
($P_UIFRNUM contains the number of the currently set frame).

All other stored settable $P_UIFR frames are called up by specifying the appropriate number $P_UIFR[n].

For predefined frame variables and user-defined frames, specify the name, e.g., $P_IFRAME.

Calling data

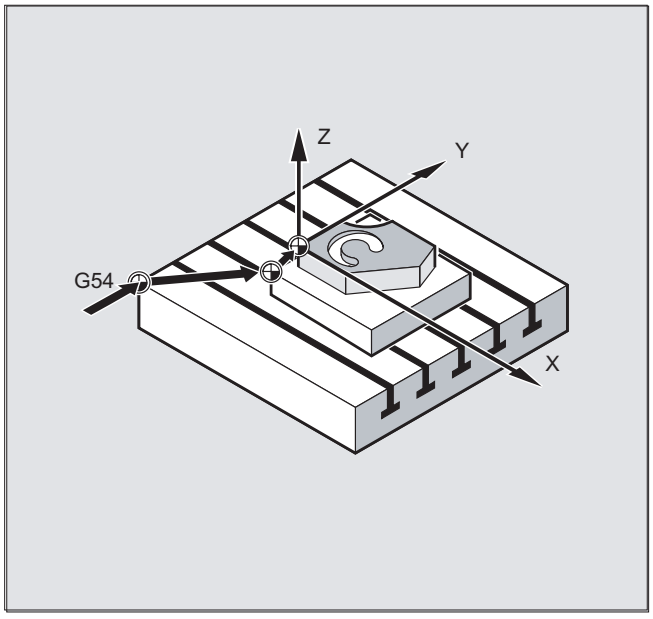
The axis name and the frame component of the value you want to access or modify are written in square brackets, e.g., [X, RT] or [Z, MI].

5.2.3 Linking complete frames

Function

A complete frame can be assigned to another frame or frames can be chained to each other in the NC program.

Frame chaining is suitable for the description of several workpieces, arranged on a pallet, which are to be machined in the same process.



The frame components can only contain intermediate values for the description of pallet tasks. These are chained to generate various workpiece zeroes.

Syntax

Assigning frames

```
DEF FRAME SETTING1                    ; Assign the values of the user frame
SETTING1=CTRANS(X,10)                 ; SETTING1 to the current programmable
$P_PFRAME=SETTING1                    ; frame.
DEF FRAME SETTING4                    ; The current programmable frame is
SETTING4=$P_PFRAME                    ; stored temporarily and can be
$P_PFRAME=SETTING4                    ; recalled.
```

Frame chains

The frames are chained in the programmed sequence. The frame components (translations, rotations, etc.) are executed additively in succession.

$P_IFRAME=$P_UIFR[15]:$P_UIFR[16]	$P_UIFR[15] contains, for example, data for zero offsets. The data of $P_UIFR[16], e.g., data for rotations, are subsequently processed additively.
$P_UIFR[3]=$P_UIFR[4]:$P_UIFR[5]	The settable frame 3 is created by chaining the settable frames 4 and 5.

Note

The frames must be linked with each other using the concatenation colon **:** .

5.2.4 Defining new frames (DEF FRAME)

Function

In addition to the predefined settable frames described above, you also have the option of creating new frames. This is achieved by creating variables of type FRAME to which you can assign a name of your choice.

You can use the functions CTRANS, CROT, CSCALE and CMIRROR to assign values to your frames in the NC program.

Syntax

```
DEF FRAME PALETTE1

PALETTE1=CTRANS(…):CROT(…)…
```

Significance

`DEF FRAME`	Creating new frames.
`PALETTE1`	Name of the new frame
`=CTRANS(...):` `CROT(...)...`	Assign values to the possible functions

5.3 Coarse and fine offsets (CFINE, CTRANS)

Function

Fine offset

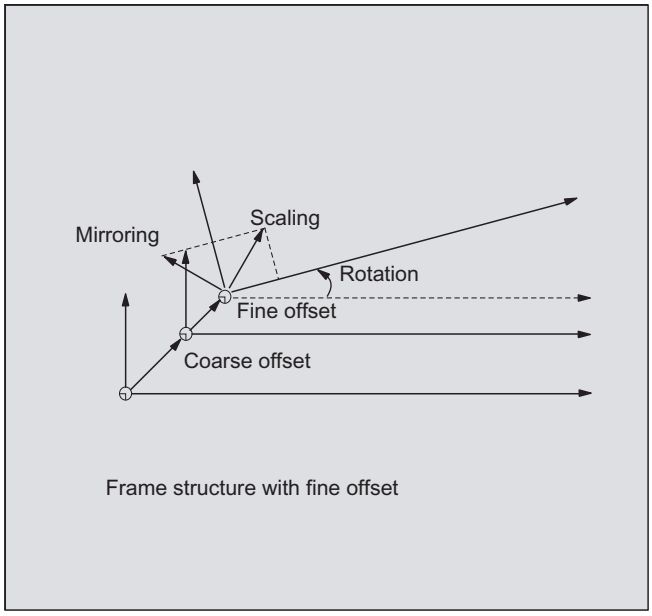
The fine offset of a frame is programmed with the `CFINE(...)` command.

Note

Release of the fine offset via MD18600 $MN_MM_FRAME_FINE_TRANS = 1

Coarse offset

The coarse offset of a frame is programmed with the `CTRANS(...)` command.



Frame structure with fine offset

Coarse and fine offset add up to the total offset.

Syntax

Fine offset

Using the example of the data management frame `$P_UIFR`:

- Complete frame
  - `$P_UIFR[<n>] = CFINE(<K1>,<value>)`
  - `$P_UIFR[<n>] = CFINE(<K1>,<value>, <K2,<value>)`
  - `$P_UIFR[<n>] = CFINE(<K1>,<value>, <K2,<value>, <K3,<value>)`
- Frame component
  - `$P_UIFR[<n>,<coordinate>,FI] = <value>`

Coarse offset

Using the example of the data management frame $P_UIFR:

- Complete frame
  - $P_UIFR[<n>] = CTRANS(<K1>,<value>)
  - $P_UIFR[<n>] = CTRANS(<K1>,<value>, <K2,<value>)
  - $P_UIFR[<n>] = CTRANS(<K1>,<value>, <K2,<value>, <K3,<value>)
- Frame component
  - $P_UIFR[<n>,<coordinate>,TR] = <value>

Programmable frame $P_PFRAME also:

- TRANS <K1> <value>
- TRANS <K1> <value> <K2> <value>
- TRANS <K1> <value> <K2> <value> <K3> <value>

Meaning

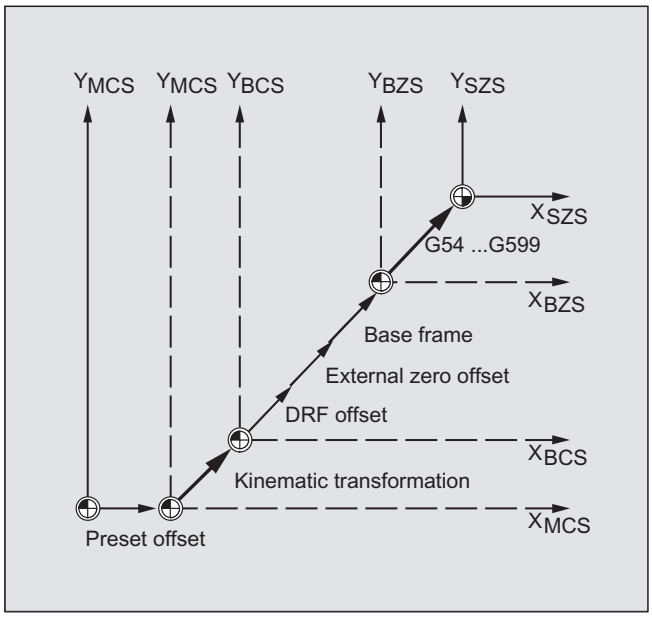
CFINE:	Fine offset, additive offset (translation).
CTRANS:	Coarse offset, absolute offset (translation).
TRANS:	Programmable frame: Coarse offset, absolute offset (translation).
X, Y, Z:	Coordinates
<Kn>:	Coordinate X, Y or Z
<value>:	Offset value

5.4 External zero offset

Function

This is another way of moving the zero point between the basic and workpiece coordinate system.

Only linear translations can be programmed with the external zero offset.



Programming

The $AA_ETRANS offset values are programmed by assigning the axis-specific system variables.

Assigning offset value

```
$AA_ETRANS[axis]=RI
```

RI is the arithmetic variable of type REAL that contains the new value.

The external offset is generally set by the PLC and not specified in the parts program.

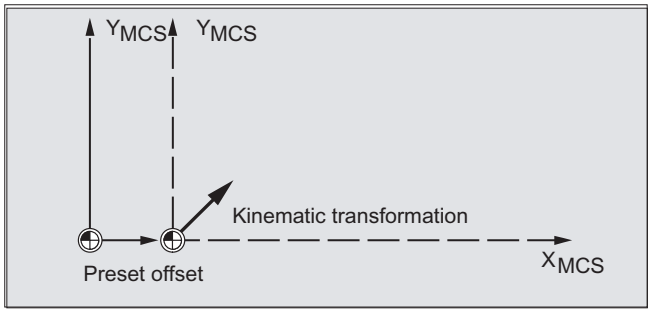
Note

The value entered in the parts program only becomes active when the corresponding signal is enabled at the VDI interface
(NCU-PLC interface).

5.5 Preset offset with PRESETON

Function

For special applications, it may be necessary to assign an already referenced machine axis a new actual value using PRESETON. This corresponds to a zero offset in the machine coordinate system.



CAUTION

No reference coordinates

After PRESETON, the machine axis is in the "non-referenced" status. We therefore recommend that the function is only used for machine axes that do not require a reference point. In order to restore the original machine coordinate system, the machine axis must be re-referenced, e.g. with G74 (reference point approach).

References:
Programming Manual, Fundamentals

Syntax

```
PRESETON(<axis_1>,<value_1>,<axis_2>,<value_2>,…)
```

Note

PRESETON can be used to program preset offsets for up to eight axes.

Meaning

PRESETON:	Predefined procedure for set actual value
<axis_...>:	Identifier of the machine axis whose machine zero point is to be changed
	Range of values: All axis identifiers defined in the channel
<value_...>:	New actual value of the machine axis in the machine coordinate system

Example

Geometry axis: A

Associated machine axis: X1

Program code	Comment
N10 G0 A100	;Axis A travels to position 100.
N20 PRESETON(X1,50)	; At position 100, machine axis X1 receives the new actual value 50 => new actual value display: - Axis X1, MCS: 50 - Axis A, WCS: 50
N30 A100	; Axis A travels 50 mm to position 100.

References

For programming of the preset offset in synchronized actions, see:

Function Manual, Synchronized Actions; Section: "Actions in synchronized actions" > "Set actual value (PRESETON)"

5.6 Frame calculation from three measuring points in space (MEAFRAME)

Function

The MEAFRAME function is used to support measuring cycles. It calculates the frame from three ideal points and the corresponding measured points.

When a workpiece is positioned for machining, its position relative to the Cartesian machine coordinate system is generally both offset and rotated in relation to its ideal position. For exact machining or measuring either a costly physical adjustment of the part is required or the motions defined in the part program must be changed.

A frame can be defined by sampling three points in space whose ideal positions are known. A touch-trigger probe or optical sensor is used for sampling that touches special holes precisely fixed on the supporting plate or probe balls.

Syntax

```
MEAFRAME(<ideal points>,<measuring points>,<quality>)
```

Meaning

`MEAFRAME`:	Function call
`<ideal points>`:	2-dim. REAL array containing the three coordinates of the ideal points
`<measuring points>`:	2-dim. REAL array containing the three coordinates of the measured points

<quality>: Variable with which information on the quality of the FRAME calculation is returned

Type: VAR REAL

Value:		
	-1	The ideal points are almost on a straight line: The frame could not be calculated. The returned FRAME variable contains a neutral frame.
	-2	The measuring points are almost on a straight line: The frame could not be calculated. The returned FRAME variable contains a neutral frame.
	-4	The calculation of the rotation matrix failed for a different reason.
	≥ 0.0	Sum of distortions (distances between the points), that are required to transform the measured triangle into a triangle that is congruent to the ideal triangle.

Note

Quality of the measurement

In order to map the measured coordinates onto the ideal coordinates using a rotation and a translation, the triangle formed by the measured points must be congruent to the ideal triangle. This is achieved by means of a compensation algorithm that minimizes the sum of squared deviations needed to reshape the measured triangle into the ideal triangle.

Since the effective distortion can be used to judge the quality of the measurement, MEAFRAME returns it as an additional variable.

Note

The frame created by MEAFRAME can be transformed by the ADDFRAME function into another frame in the frame chain (see example "Chaining with ADDFRAME").

Examples

Example 1:

Part program 1:

Program code

```
...
DEF FRAME CORR_FRAME
```

Setting measuring points:

```
Program code                                                    Comment
DEF REAL IDEAL_POINT[3,3]=SET(10.0,0.0,0.0,0.0,10.0,0.0,0.0,0.0,10.0)
DEF REAL MEAS_POINT[3,3]=SET(10.1,0.2,-0.2,-0.2,10.2,0.1,-0.2,0.2,9.8)          ; For test.

DEF REAL FIT_QUALITY=0
DEF REAL ROT_FRAME_LIMIT=5                                      ; Permits max. five degree rotation of the part
                                                                  position
DEF REAL FIT_QUALITY_LIMIT=3                                    ; Permits max. three mm offset between the
                                                                  ideal and the measured triangle
DEF REAL SHOW_MCS_POS1[3]
DEF REAL SHOW_MCS_POS2[3]
DEF REAL SHOW_MCS_POS3[3]
```

```
Program code                                                    Comment
N100 G01 G90 F5000
N110 X0 Y0 Z0
N200 CORR_FRAME=MEAFRAME(IDEAL_POINT,MEAS_POINT,FIT_QUALITY)
N230 IF FIT_QUALITY < 0
SETAL(65000)
GOTOF NO_FRAME
ENDIF
N240 IF FIT_QUALITY > FIT_QUALITY_LIMIT
SETAL(65010)
GOTOF NO_FRAME
ENDIF
N250 IF CORR_FRAME[X,RT] > ROT_FRAME_LIMIT                      ; Limiting the 1st RPY angle
SETAL(65020)
GOTOF NO_FRAME
ENDIF
N260 IF CORR_FRAME[Y,RT] > ROT_FRAME_LIMIT                      ; Limiting the 2nd RPY angle
SETAL(65021)
GOTOF NO_FRAME
ENDIF
N270 IF CORR_FRAME[Z,RT] > ROT_FRAME_LIMIT                      ; Limiting the 3rd RPY angle
SETAL(65022)
GOTOF NO_FRAME
ENDIF
N300 $P_IFRAME=CORR_FRAME                                       ; Activate sample frame with settable
                                                                  frame.
                                                                ; Check frame by positioning the geometry
                                                                  axes to the ideal point.
```

```
Program code                                                    Comment
N400 X=IDEAL_POINT[0,0] Y=IDEAL_POINT[0,1]
Z=IDEAL_POINT[0,2]
N410 SHOW_MCS_POS1[0]=$AA_IM[X]
N420 SHOW_MCS_POS1[1]=$AA_IM[Y]
N430 SHOW_MCS_POS1[2]=$AA_IM[Z]
N500 X=IDEAL_POINT[1,0] Y=IDEAL_POINT[1,1] Z=IDEAL_POINT[1,2]
N510 SHOW_MCS_POS2[0]=$AA_IM[X]
N520 SHOW_MCS_POS2[1]=$AA_IM[Y]
N530 SHOW_MCS_POS2[2]=$AA_IM[Z]
N600 X=IDEAL_POINT[2,0] Y=IDEAL_POINT[2,1] Z=IDEAL_POINT[2,2]
N610 SHOW_MCS_POS3[0]=$AA_IM[X]
N620 SHOW_MCS_POS3[1]=$AA_IM[Y]
N630 SHOW_MCS_POS3[2]=$AA_IM[Z]
N700 G500                                                       ; Deactivate settable frame as with zero
                                                                  frame (no value entered, pre-assigned).
No_FRAME                                                        ; Deactivate settable frame, as pre-
                                                                  assigned with zero frame (no value
                                                                  entered).
M0
M30
```

Example 2: Chaining of frames

Chaining of MEAFRAME for offsets

The MEAFRAME function returns an offset frame. If this offset frame is chained to the settable frame $P_UIFR[1] that was active during the call of the function (e.g. G54), a settable frame is provided for further conversions for the traversing or machining.

Chaining with ADDFRAME

If you want this offset frame in the frame chain to apply at a different position or if other frames are active before the settable frame, the ADDFRAME function can be used for chaining into one of the channel basic frames or a system frame.

The following must not be active in the frames:

- Mirroring with MIRROR
- Scaling with SCALE

The input parameters for the setpoints and actual values are the workpiece coordinates. These coordinates must always be specified metrically or in inches (G71/G70) and radius-related (DIAMOF) in the basic system of the control.

References:
For further information on ADDFRAME, see:
Function Manual, Basic Functions; K2: Axis Types, Coordinate Systems, Frames

5.7 NCU global frames

Function

Only one set of NCU global frames is used for all channels on each NCU. NCU global frames can be read and written from all channels. The NCU global frames are activated in the respective channel.

Channel axes and machine axes with offsets can be scaled and mirrored by means of global frames.

Geometrical relationships and frame chains

With global frames there is no geometrical relationship between the axes. It is therefore not possible to perform rotations or program geometry axis identifiers.

- Rotations cannot be used on global frames. The programming of a rotation is denied with alarm: "18310 Channel %1 Block %2 Frame: rotation not allowed" is displayed.
- It is possible to chain global frames and channel-specific frames. The resulting frame contains all frame components including the rotations for all axes. The assignment of a frame with rotation components to a global frame is denied with alarm "Frame: rotation not allowed".

NCU global frames

NCU global basic frames $P_NCBFR[n]

Up to eight NCU global basic frames can be configured:

Channel-specific basic frames can also be available.

Global frames can be read and written from all channels of an NCU. When writing global frames, the user must ensure channel coordination. This can be implemented, for example, through wait markers (WAITMC).

Machine manufacturer

The number of global basic frames is configured via the machine data.

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

NCU global settable frames $P_UIFR[n]

All settable frames G500, G54...G599 can be configured NCU-globally or channel-specifically.

Machine manufacturer

All settable frames can be reconfigured as global frames with the aid of machine data MD18601 $MN_MM_NUM_GLOBAL_USER_FRAMES.

Channel axis identifiers and machine axis identifiers can be used as axis identifiers in frame program commands. Programming of geometry identifiers is rejected with an alarm.

5.7.1 Channel-specific frames ($P_CHBFR, $P_UBFR)

Function

Settable frames or basic frames can be read and written via the part program and via the OPI by the operator and by the PLC.

The fine offset can also be used for global frames. Suppression of global frames also takes place, as is the case with channel-specific frames, via G53, G153, SUPA and G500.

Machine manufacturer

The number of basic frames can be configured in the channel via the machine data MD28081 $MC_MM_NUM_BASE_FRAMES. The standard configuration is designed for at least one basic frame per channel. A maximum of eight basic frames are supported per channel. In addition to the eight basic frames, there can also be eight NCU global basic frames in the channel.

Channel-specific frames

$P_CHBFR[n]

System variable $P_CHBFR[n] can be used to read and write the basic frames. When a basic frame is written, the chained total basic frame is not activated until the execution of a G500, G54...G599 instruction. The variable is used primarily for storing write operations to the basic frame on HMI or PLC. These frame variables are saved by the data backup.

First basic frame in the channel

The basic frame with array index 0 is not activated simultaneously when writing to the predefined $P_UBFR variable, but rather activation only takes place on execution of a G500, G54...G599 instruction. The variable can also be read and written in the program.

$P_UBFR

$P_UBFR is identical to $P_CHBFR[0]. One basic frame always exists in the channel by default, so that the system variable is compatible with older versions. If there is no channel-specific basic frame, an alarm is issued at read/write: "Frame: instruction not permissible".

5.7.2 Frames active in the channel

Function

Frames active in the channel are entered from the part program via the relevant system variables of these frames. This also includes system frames. The current system frame can be read and written in the part program via these system variables.

Frames currently active in the channel

Overview

Current system frames	For:
$P_PARTFRAME	TCARR and PAROT
$P_SETFRAME	Preset actual value memory and scratching
$P_EXTFRAME	External zero offset
$P_NCBFRAME[n]	Current NCU global basic frames
$P_CHBFRAME[n]	Current channel basic frames
$P_BFRAME	Current first basic frame in the channel
$P_ACTBFRAME	Complete basic frame
$P_CHBFRMASK and $P_NCBFRMASK	Complete basic frame
$P_IFRAME	Current settable frame
Current system frames	For:
$P_TOOLFRAME	TOROT and TOFRAME
$P_WPFRAME	Workpiece reference points
$P_TRAFRAME	Transformations
$P_PFRAME	Current programmable frame
Current system frame	For:
$P_CYCFRAME	Cycles
P_ACTFRAME	Current total frame
FRAME chaining	Current frame is made up of the complete basic frame

$P_NCBFRAME [n] Current NCU global basic frames

System variable $P_NCBFRAME[n] can be used to read and write the current global basic frame field elements. The resulting total basic frame is calculated by means of the write process in the channel.

The modified frame is activated only in the channel in which the frame was programmed. If the frame is to be modified for all channels of an NCU, $P_NCBFR[n] and $P_NCBFRAME[n] must be written simultaneously. The other channels must then activate the frame, e.g. with G54. Whenever a basic frame is written, the complete basic frame is calculated again.

$P_CHBFRAME[n] Current channel basic frames

System variable $P_CHBFRAME[n] can be used to read and write the current channel basic frame field elements. The resulting complete basic frame is calculated by means of the write process in the channel. Whenever a basic frame is written, the complete basic frame is calculated again.

$P_BFRAME Current first basic frame in the channel

The predefined frame variable $P_BFRAME can be used to read and write the current basic frame with the array index 0, which is valid in the channel, in the part program. The written basic frame is immediately included in the calculation.

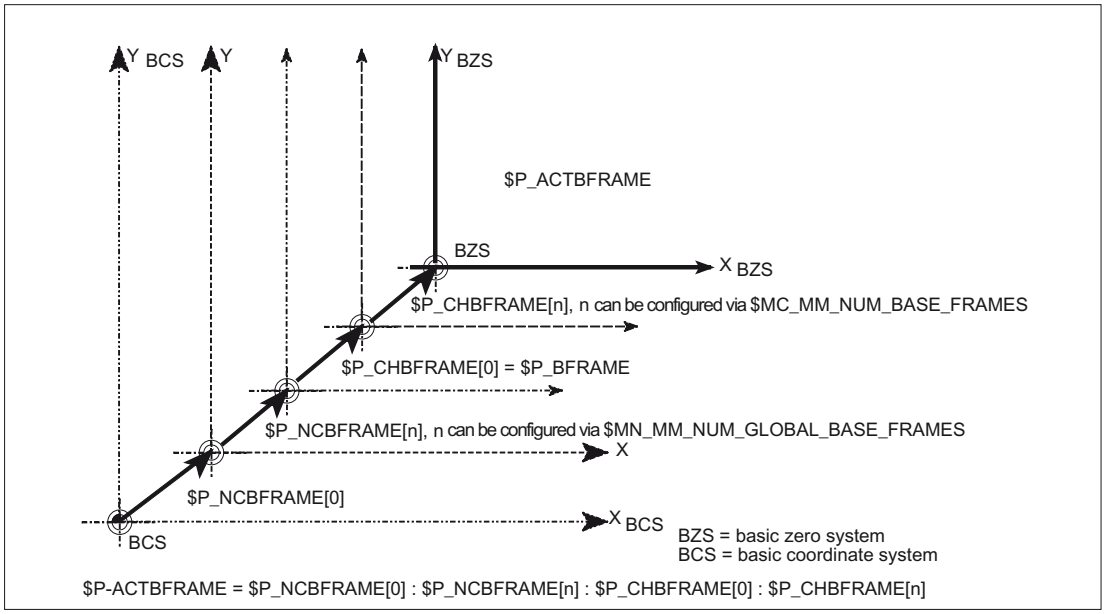
$P_BFRAME is identical to $P_CHBFRAME[0]. The system variable always has a valid default value. If there is no channel-specific basic frame, an alarm is issued at read/write: "Frame: instruction not permissible".

$P_ACTBFRAME Complete basic frame

The $P_ACTFRAME variable determines the chained complete basic frame. The variable is read-only.

$P_ACTFRAME corresponds to:

$P_NCBFRAME[0] : ... : $P_NCBFRAME[n] : $P_CHBFRAME[0] : ... : $P_CHBFRAME[n].



$P_CHBFRMASK and $P_NCBFRMASK Complete basic frame

The user can select which basic frames are to be included in the calculation of the "Complete" basic frame via the system variables $P_CHBFRMASK and $P_NCBFRMASK. The variables can only be programmed in the program and read via the OPI. The value of the variable is interpreted as a bit mask and specifies which basic frame field element of $P_ACTFRAME is to be included in the calculation.

$P_CHBFRMASK can be used to specify which channel-specific basic frames and $P_NCBFRMASK can be used to specify which NCU global basic frames are to be included in the calculation.

The complete basic frame and the complete frame are recalculated with the programming of the variables. After a reset and in the basic setting, the values of $P_CHBFRMASK and $P_NCBFRMASK are as follows:

$P_CHBFRMASK = $MC_CHBFRAME_RESET_MASK

$P_NCBFRMASK = $MC_CHBFRAME_RESET_MASK

Example:

```
$P_NCBFRMASK = 'H81' ;$P_NCBFRAME[0] : $P_NCBFRAME[7]
$P_CHBFRMASK = 'H11' ;$P_CHBFRAME[0] : $P_CHBFRAME[4]
```

$P_IFRAME Current settable frame

The predefined frame variable $P_IFRAME can be used to read and write the current settable frame, which is valid in the channel, in the part program. The written settable frame is immediately included in the calculation.

In the case of NCU global settable frames, the modified frame acts only in the channel in which the frame was programmed. If the frame is to be modified for all channels of an NCU, $P_UIFR[n] and $P_IFRAME must be written simultaneously. The other channels must then activate the corresponding frame, e.g. with G54.

$P_PFRAME Current programmable frame

$P_PFRAME is the programmable frame that results from the programming of TRANS/ATRANS, G58/G59, ROT/AROT, SCALE/ASCALE, MIRROR/AMIRROR or from the assignment of CTRANS, CROT, CMIRROR, CSCALE to the programmable frame.

Current, programmable frame variable that establishes the reference between the settable zero system (SZS) and the workpiece coordinate system (WCS).

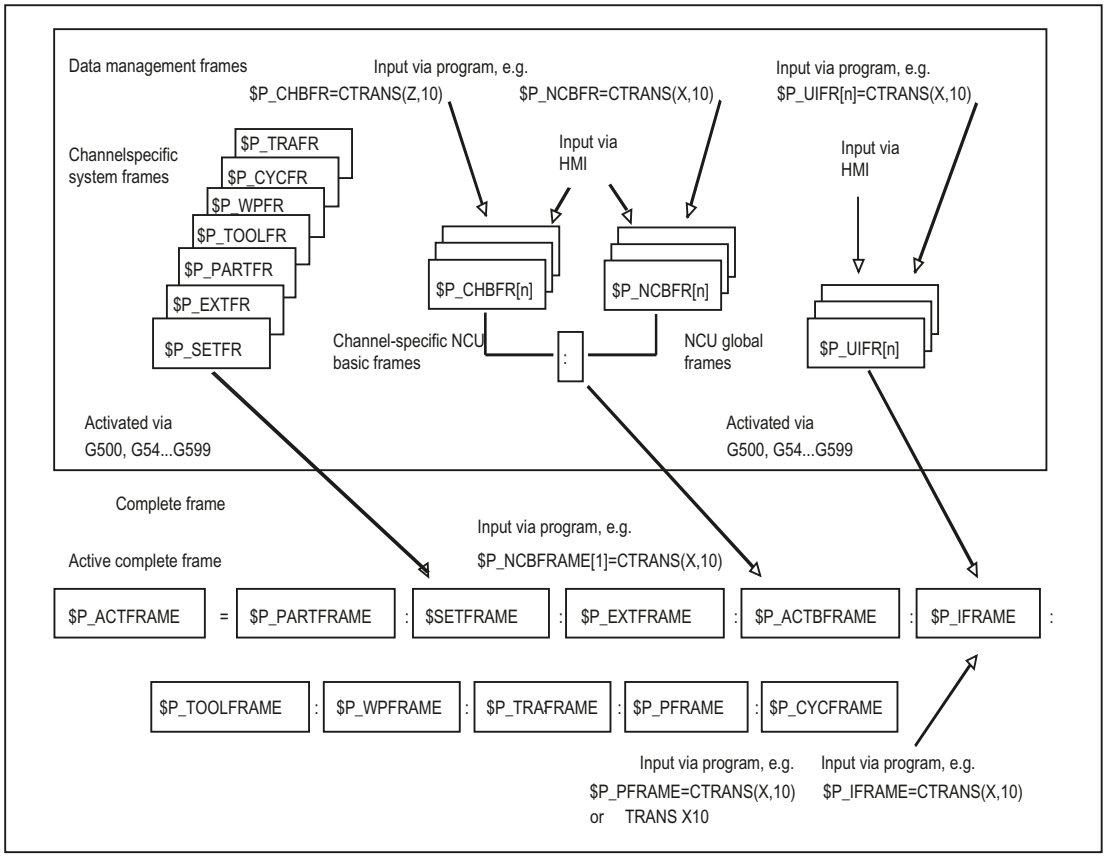
P_ACTFRAME Current complete frame

The resulting current complete frame $P_ACTFRAME is now a chain of all basic frames, the current settable frame and the programmable frame. The current frame is always updated whenever a frame component is changed.

`$P_ACTFRAME` corresponds to:

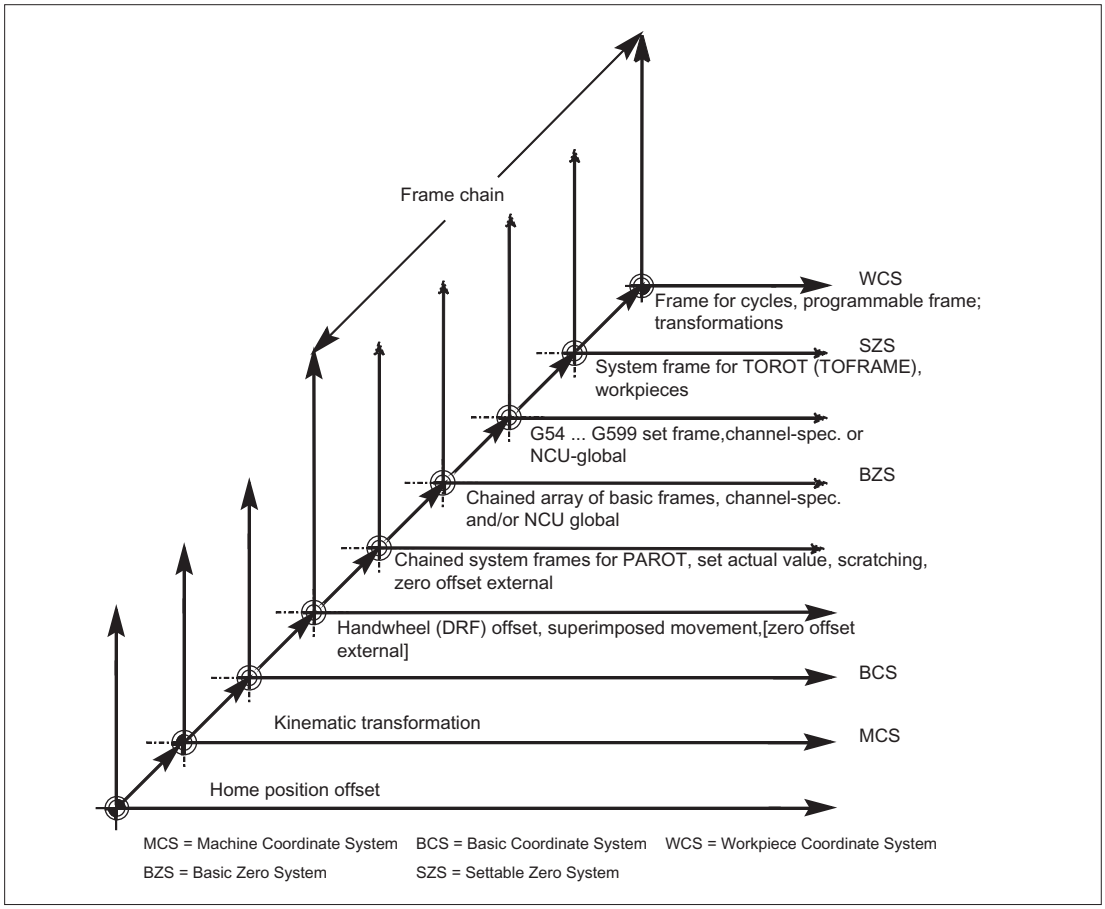
`$P_PARTFRAME : $P_SETFRAME : $P_EXTFRAME : $P_ACTBFRAME : $P_IFRAME :`

`$P_TOOLFRAME : $P_WPFRAME : $P_TRAFRAME : $P_PFRAME : $P_CYCFRAME`



Frame chaining

The current frame is composed of the complete basic frame, the settable frame, the system frame and the programmable frame in accordance with current complete frame specified above.



Transformations 6

6.1 General programming of transformation types

General function

You can choose to program transformation types with suitable parameters in order to adapt the controller to various machine kinematics. These parameters can be used to declare both the orientation of the tool in space and the orientation movements of the rotary axes accordingly for the selected transformation.

In three-, four-, and five-axis transformations, the programmed positional data always relates to the tip of the tool, which is tracked orthogonally to the machined surface in space. The Cartesian coordinates are converted from the basic coordinate system to the machine coordinate system and relate to the geometry axes. These describe the operating point. Virtual rotary axes describe the orientations of the tool in space and are programmed with TRAORI.

In the case of kinematic transformation, positions can be programmed in the Cartesian coordinate system. The controller maps the Cartesian coordinate system traversing movements programmed with TRANSMIT, TRACYL and TRAANG to the traversing movements of the real machine axes.

Programming

Three, four and five axis transformations (TRAORI)

The orientation transformation declared is activated with the TRAORI command and the three possible parameters for transformation number, orientation vector and rotary axis offsets.

```
TRAORI(transformation number, orientation vector, rotary axis offsets)
```

Kinematic transformations

`TRANSMIT(transformation number)` declared transformations are examples of kinematic transformation.

```
TRACYL(working diameter, transformation number)
```

```
TRAANG(angle of offset axis, transformation number)
```

Deactivate active transformation

`TRAFOOF` can be used to deactivate the currently active transformation.

Orientation transformation

Three, four and five axis transformations (TRAORI)

For the optimum machining of surfaces configured in space in the working area of the machine, machine tools require other axes in addition to the three linear axes X, Y and Z. The additional axes describe the orientation in space and are called orientation axes in subsequent sections. They are available as rotary axes on four types of machine with varying kinematics.

1. Two-axis swivel head, e.g. cardanic tool head with one rotary axis parallel to a linear axis on a fixed tool table.
2. Two-axis rotary table, e.g. fixed swivel head with tool table, which can rotate about two axes.
3. Single-axis swivel head and single-axis rotary table, e.g. one rotatable swivel head with rotated tool for tool table, which can rotate about one axis.
4. Two-axis swivel head and single-axis rotary table, e.g. on tool table, which can rotate about one axis, and one rotatable swivel head with tool, which can rotate about itself.

3- and 4-axis transformations are special types of 5-axis transformation and are programmed in the same way as 5-axis transformations.

The functional scope of "**generic 3-/4-/5-/6-axis transformation**" is suitable both for transformations for orthogonal rotary axes and transformations for the universal milling head and, like all other orientation transformations, can also be activated for these four machine types with TRAORI. In generic 5-/6-axis transformation, tool orientation has an additional third degree of freedom, whereby the tool can be rotated about its own axis relative to the tool direction so that it can be directed as required in space.

References: /FB3/ Function Manual, Special Functions; 3- to 5-Axis Transformation (F2)

Initial tool orientation setting regardless of kinematics

ORIRESET

If an orientation transformation is active using TRAORI, then ORIRESET can be used to specify the initial settings of up to 3 orientation axes with the optional parameters A, B, C. The order in which the programmed parameters are assigned to the round axes depends on the orientation axis order defined by the transformation. Programming ORIRESET(A, B, C) results in the orientation axes moving in linear and synchronous motion from their current position to the specified initial setting position.

Kinematic transformations

TRANSMIT and TRACYL

For milling on turning machines, either

1. Face machining in the turning clamp with TRANSMIT or
2. Machining of grooves with any path on cylindrical bodies with TRACYL

can be programmed for the transformation declared.

TRAANG

If the option of setting the infeed axis for inclined infeed is required (for grinding technology, for example), TRAANG can be used to program a configurable angle for the transformation declared.

Cartesian PTP travel

Kinematic transformation also includes the so-called "Cartesian PTP travel" for which up to 8 different articulated joint positions STAT= can be programmed. Although the positions are programmed in a Cartesian coordinate system, the movement of the machine occurs in the machine coordinates.

References:
/FB2/ Function Manual, Extended Functions; Kinematic Transformation (M1)

Chained transformations

Two transformations can be switched one after the other. For the second transformation chained here, the motion parts for the axes are taken from the first transformation.

The first transformation can be:

- Orientation transformation TRAORI
- Polar transformation TRANSMIT
- Cylinder transformation TRACYL
- Inclined axis transformation TRAANG

The second transformation must be a TRAANG type transformation for an inclined axis.

6.1.1 Orientation movements for transformations

Travel movements and orientation movements

The traversing movements of the programmed orientations are determined primarily by the type of machine. For three-, four-, and five-axis type transformations with TRAORI, the rotary axes or pivoting linear axes describe the orientation movements of the tool.

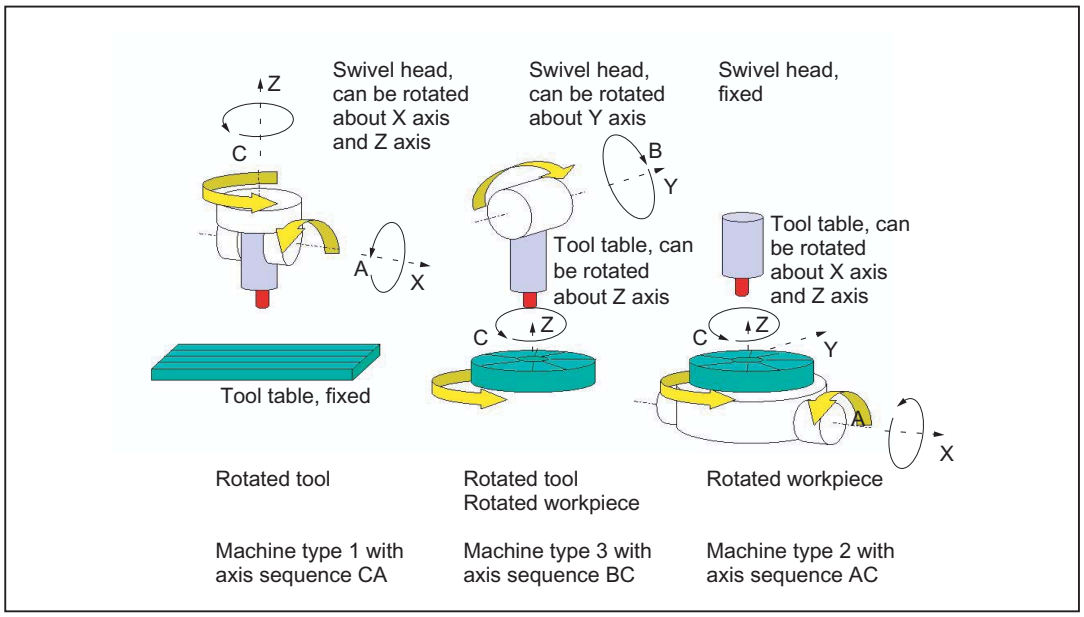
Changes in the position of the rotary axes involved in the orientation transformation will induce compensating movements on the remaining machine axes. The position of the tool tip remains unchanged.

Orientation movements of the tool can be programmed using the rotary axis identifiers A…, B…, C… of the virtual axes as appropriate for the application either by entering Euler or RPY angles or directional or surface normal vectors, normalized vectors for the rotary axis of a taper or for intermediate orientation on the peripheral surface of a taper.

In the case of kinematic transformation with TRANSMIT, TRACYL and TRAANG, the controller maps the programmed Cartesian coordinate system traversing movements to the traversing movements of the real machine axes.

Machine kinematics for three, four and five axis transformation (TRAORI)

Either the tool or the tool table can be rotatable with up to two rotary axes. A combination of swivel head and rotary table (single-axis in each case) is also possible.



Machine type	Programming of orientation
Three-axis transformation machine types 1 and 2	Programming of tool orientation only in the plane, which is perpendicular to the rotary axis. There are **two** translatory axes (linear axes) and **one** axis of rotation (rotary axis).
Four-axis transformation machine types 1 and 2	Programming of tool orientation only in the plane, which is perpendicular to the rotary axis. There are **three** translatory axes (linear axes) and **one** axis of rotation (rotary axis).
Five-axis transformation machine types 3	Programming of orientation transformation. Kinematics with **three** linear axes and **two** orthogonal rotary axes.
Single-axis swivel head and single-axis rotary table	The rotary axes are parallel to two of the three linear axes. The first rotary axis is moved by two Cartesian linear axes. It rotates the third linear axis with the tool. The second rotary axis rotates the workpiece.

Generic 5/6-axis transformations

Machine type	Programming of orientation transformation
Generic five/six-axis transformation machine types 4 Two-axis swivel head with tool which rotates around itself and single-axis rotary table	Programming of orientation transformation. Kinematics with **three** linear axes and **three** orthogonal rotary axes. The rotary axes are parallel to two of the three linear axes. The first rotary axis is moved by two Cartesian linear axes. It rotates the third linear axis with the tool. The second rotary axis rotates the workpiece. The basic tool orientation can also be programmed with additional rotation of the tool around itself with the THETA rotary angle.

When calling "generic three-, four-, and five/six-axis transformation", the basic orientation of the tool can also be transferred. The restrictions in respect of the directions of the rotary axes no longer apply. If the rotary axes are not exactly vertical to one another or existing rotary axes are not exactly parallel with the linear axes, "generic five-/six-axis transformation" can provide better results in respect of tool orientation.

Kinematic transformations TRANSMIT, TRACYL and TRAANG

For milling on turning machines or an axis that can be set for inclined infeed during grinding, the following axis arrangements apply by default in accordance with the transformation declared:

TRANSMIT	Activation of polar transformation
Face machining in the turning clamp	A rotary axis An infeed axis vertical to the axis of rotation A longitudinal axis parallel to the axis of rotation

TRACYL	Activation of the cylinder surface transformation
Machining of grooves with any path on cylindrical bodies	A rotary axis An infeed axis vertical to the axis of rotation A longitudinal axis parallel to the axis of rotation

TRAANG	Activation of the inclined axis transformation
Machining with an oblique infeed axis	A rotary axis An infeed axis with parameterizable angle A longitudinal axis parallel to the axis of rotation

Cartesian PTP travel

The machine moves in machine coordinates and is programmed with:

TRAORI	Activation of transformation
PTP Point-to-point motion	Approach position in Cartesian coordinate system (MCS)
CP	Path motion of Cartesian axes in the BCS
STAT	Position of the articulated joints is dependent on the transformation
TU	The angle at which the axes traverse on the shortest path

PTP transversal with generic 5/6-axis transformation

The machine is moved using machine coordinates and the tool orientation, where the movements can be programmed both using round axis positions and using Euler and/or RPY angle vectors irrespective of the kinematics or the direction vectors.

Round axis interpolation, vector interpolation with large circle interpolation or interpolation of the orientation vector on a peripheral surface of a taper are possible in such cases.

Example: Three- to five-axis transformation on a universal milling head

The machine tool has at least five axes:

- Three translatory axes for movements in straight lines, which move the operating point to any position in the working area.
- Two rotary swivel axes arranged at a configurable angle (usually 45 degrees) allow the tool to swivel to positions in space that are limited to a half sphere in a 45-degree configuration.

6.1.2 Overview of orientation transformation TRAORI

Programming types available in conjunction with TRAORI

Machine type	Programming with active transformation TRAORI
Machine types 1, 2, or 3 two-axis swivel head or two-axis rotary table or a combination of single-axis swivel head and single-axis rotary table.	The axis sequence of the orientation axes and the orientation direction of the tool can either be configured on a **machine-specific** basis using machine data depending on the machine kinematics or on a **workpiece-specific** basis with programmable orientation independently of the machine kinematics. The directions of rotation of the orientation axes in the reference system are programmed with: - ORIMKS reference system = machine coordinate system - ORIWKS reference system = workpiece coordinate system The default setting is ORIWKS. Programming of orientation axes with: A, B, C of the machine axis position direct A2, B2, C2 angle programming virtual axes with - ORIEULER via Euler angle (standard) - ORIRPY via RPY angle - ORIVIRT1 via virtual orientation axes 1st definition - ORIVIRT2 via virtual orientation axes 2nd definition with differentiation between the interpolation type: **linear interpolation** - ORIAXES of orientation axes or machine axes **large radius circle interpolation** (interpolation of the orientation vector) - ORIVECT from orientation axes Programming orientation axes by specifying A3, B3, C3 of the vector components (direction/surface normal) Programming the resulting tool orientation A4, B4, C4 of the vector surface normal at the beginning of the block A5, B5, C5 of the vector perpendicular to the surface at the end of the block LEAD leading angle for tool orientation TILT tilt angle for the tool orientation

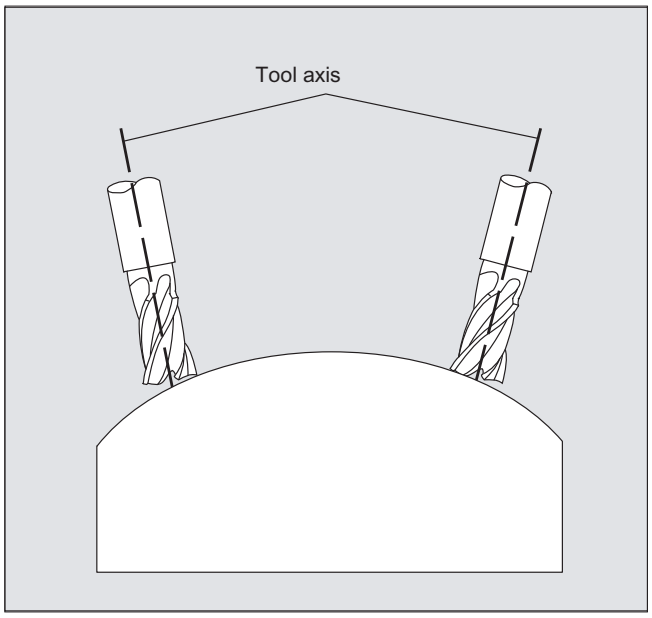
Machine type	Programming with active transformation TRAORI
	Interpolation of the orientation vector on a taper peripheral surface Orientation changes to a taper peripheral surface **anywhere in space** using interpolation: - ORIPLANE in the plane (large radius circle interpolation) - ORICONCW on a taper peripheral surface in the clockwise direction - ORICONCCW on a taper peripheral surface in the counter-clockwise direction A6, B6, C6 director vector (axis of rotation of the taper) -OICONIO interpolation on a taper peripheral surface with: A7, B7, C7 intermediate vectors (initial and ultimate orientation) or - ORICONTO on the peripheral surface of a taper, tangential transition Changes in orientation in relation **to a path** with - ORICURVE specification of the movement of two contact points using PO[XH]=(xe, x2, x3, x4, x5) orientation polynomials up to the fifth degree PO[YH]=(ye, y2, y3, y4, y5) orientation polynomials up to the fifth degree PO[ZH]=(ze, z2, z3, z4, z5) orientation polynomials up to the fifth degree - ORIPATHS smoothing of orientation characteristic with A8, B8, C8 reorientation phase of tool corresponding to: direction and path length of tool during retraction movement
Machine types 1 and 3 Other machine types with additional tool rotation around itself require a 3rd rotary axis Orientation transformation, e.g. generic 6-axis transformation. Rotations of orientation vector.	Programming **of rotations** for tool orientation with LEAD angle, angle relative to surface normal vector PO[PHI] programming of a polynomial up to the fifth degree TILT angle rotation about path tangent (Z direction) PO[PSI] programming of a polynomial up to the fifth degree THETA angle of rotation (rotation about tool direction in Z) THETA= value reached at end of block THETA=AC(...) absolute non-modal switching to dimensions THETA=IC(...) non-modal switching to chain dimensions THETA=Θ_e interpolate programmed angle G90/G91 PO[THT]=(..) programming of a polynomial up to the fifth degree programming of the rotation vector - ORIROTA rotation, absolute - ORIROTR relative rotation vector - ORIROTT tangential rotation vector
Orientation relative to the path for orientation changes relative to the path or rotation of the rotary vector tangentially to the path	Changes in orientation **relative to the path** with - ORIPATH tool orientation relative to the path - ORIPATHS also in the event of a blip in the orientation characteristic programming of rotation vector - ORIROTC tangential rotation vector, rotation to path tangent

6.2 Three, four and five axis transformation (TRAORI)

6.2.1 General relationships of universal tool head

Function

To obtain optimum cutting conditions when machining surfaces with a three-dimensional curve, it must be possible to vary the setting angle of the tool.

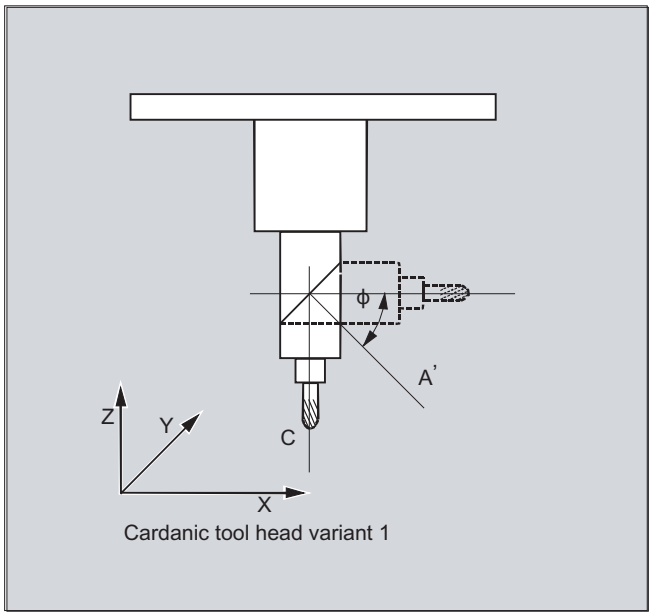


The machine design to achieve this is stored in the axis data.

5-axis transformation

Cardanic tool head

Three linear axes (X, Y, Z) and two orientation axes (C, A) define the setting angle and the operating point of the tool here. One of the two orientation axes is created as an inclined axis, in our example A' - in many cases, placed at 45°.

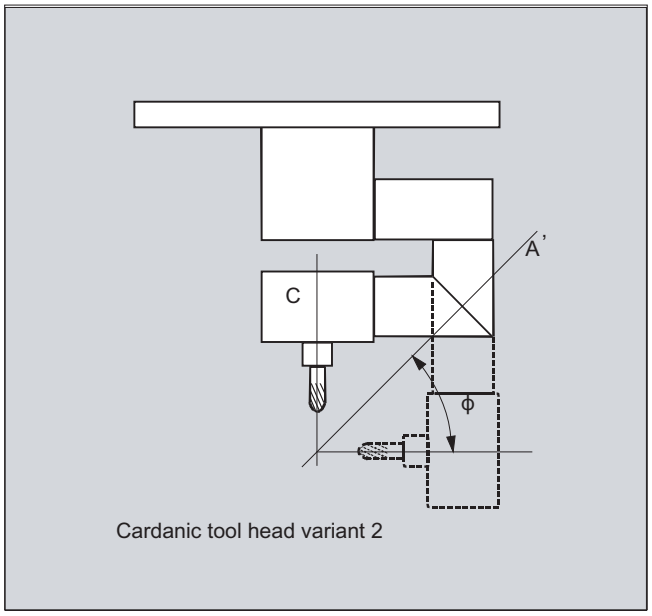


Cardanic tool head variant 1

In the examples shown here, you can see the arrangements as illustrated by the CA machine kinematics with the Cardanic tool head!

Machine manufacturer

The axis sequence of the orientation axes and the orientation direction of the tool can be set up using the machine data as appropriate for the machine kinematics.



Cardanic tool head variant 2

In this example, A' lies below the angle φ to the X axis.

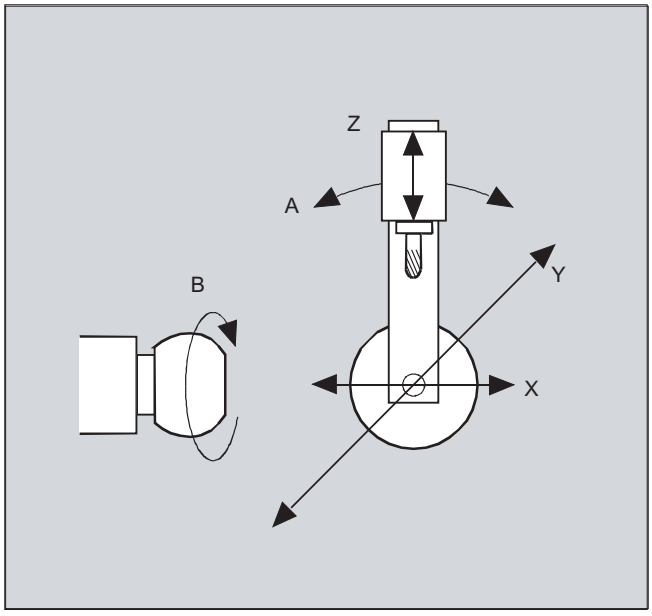
The following possible relations are generally valid:

A' lies below the angle φ to the	X axis
B' lies below the angle φ to the	Y axis
C' lies below the angle φ to the	Z axis

Angle φ can be configured in the range 0° to +89° using machine data.

With swiveling linear axis

This is an arrangement with a moving workpiece and a moving tool. The kinematics consists of three linear axes (X, Y, Z) and two orthogonally arranged rotary axes. The first rotary axis is moved, for example, over a compound slide of two linear axes, the tool standing parallel to the third linear axis. The second rotary axis turns the workpiece. The third linear axis (swivel axis) lies in the compound slide plane.



The axis sequence of the rotary axes and the orientation direction of the tool can be set up using the machine data as appropriate for the machine kinematics.

There are the following possible relationships:

Axes:	Axis sequences:
1st rotary axis	A A B B C C
2nd rotary axis	B C A C A B
Swiveled linear axis	Z Y Z X Y X

For more detailed information about configurable axis sequences for the orientation direction of the tool, see

References: /FB3/ Function Manual, Special Functions; 3- to 5-Axis Transformations (F2), Section Universal milling head, "Parameterization".

6.2.2 Three, four and five axis transformation (TRAORI)

Function

The user can configure two or three translatory axes and one rotary axis. The transformations assume that the rotary axis is orthogonal on the orientation plane.

Orientation of the tool is possible only in the plane perpendicular to the rotary axis. The transformation supports machine types with movable tool and movable workpiece.

Three- and four-axis transformations are configured and programmed in the same way as five-axis transformations.

Reference:
Function Manual, Special Functions; Multi-Axis Transformations (F2)

Syntax

```
TRAORI(<n>)

TRAORI(<n>,<X>,<Y>,<Z>,<A>,<B>)

TRAFOOF
```

Meaning

`TRAORI`:	Activates the first specified orientation transformation
`TRAORI(<n>)`:	Activates the orientation transformation specified by n
`<n>`:	Number of the transformation
	Value: 1 or 2
	Example:
	TRAORI(1) activates orientation transformation 1
`<X>,<Y>,<Z>`:	Component of orientation vector to which tool points
`<A>,<B>`:	Programmable offset for the rotary axes
`TRAFOOF`:	Deactivate transformation

Tool orientation

Depending on the orientation direction selected for the tool, the active working plane (G17, G18, G19) must be set in the NC program in such a way that tool length offset works in the direction of tool orientation.

Note

When the transformation is enabled, the positional data (X, Y, Z) always relates to the tip of the tool. Changing the positions of the rotary axes involved in the transformation causes compensating motion of the remaining machine axes - which means that the position of the tool tip remains unchanged.

Orientation transformation always points from the tool tip to the tool adapter.

Offset for orientation axes

When orientation transformation is activated an additional offset can be programmed directly for the orientation axes.

Parameters can be omitted if the correct sequence is used in programming.

Example:

```
TRAORI(, , , ,A,B)
```
; If only a single offset is to be entered

As an alternative to direct programming, the additional offset for orientation axes can also be transferred automatically from the zero offset currently active. Transfer is configured in the machine data.

Examples

```
TRAORI(1,0,0,1)          ; The basic orientation of the tool is in the Z direction

TRAORI(1,0,1,0)          ; The basic orientation of the tool is in the Z direction

TRAORI(1,0,1,1)          ; The basic orientation of the tool is in the Y/Z direction
                           (corresponds to the position -45°)
```

6.2.3 Variants of orientation programming and initial setting (ORIRESET)

Orientation programming of tool orientation with TRAORI

In conjunction with a programmable TRAORI orientation transformation, in addition to the linear axes X, Y, Z, the axis identifiers A.., B..., C... can also be used to program axis positions or virtual axes with angles or vector components. Various types of interpolation are possible for orientation and machine axes. Regardless of which PO[angle] orientation polynomials and PO[axis] axis polynomials are currently active, a number of different types of polynomial can be programmed. These include G1, G2, G3, CIP or POLY.

Changes in tool orientation can even be programmed using orientation vectors in some cases. In such cases, the ultimate orientation of each block can be set either by means of direct programming of the vector or by programming the rotary axis positions.

Note

Variants of orientation programming for three- to five-axis transformation

In respect of three- to five-axis transformation, the following variants:

1. A, B, C direct entry of machine axis positions
2. A2, B2, C2 angular programming of virtual axes using Euler angle or RPY angle
3. A3 ,B3, C3 entry of vector components
4. LEAD, TILT entry of lead and tilt angles relative to the path and surface
5. A4, B4, C4 and A5, B5, C5 surface normal vector at start of block and end of block
6. A6, B6, C6 and A7, B7, C7 interpolation of orientation vector on a peripheral surface of a taper
7. A8, B8, C8 reorientation of tool, direction and path length of retracting movement

are mutually exclusive.

If an attempt is made to program mixed values, alarm messages are output.

Initial tool orientation setting ORIRESET

By programming ORIRESET (A, B, C), the orientation axes are moved in linear and synchronous motion from their current position to the specified initial setting position.

If an initial setting position is not programmed for an axis, a defined position from the associated machine data $MC_TRAFO5_ROT_AX_OFFSET_1/2 is used. Any active frames of round axles which may be present are ignored.

Note

Only if an orientation transformation is active with TRAORI(...), can an initial setting for the tool orientation regardless of kinematics be programmed without alarm 14101 using ORIRESET(...).

Examples

```
1. Example of machine kinematics CA (channel axis names C, A)
ORIRESET(90, 45)       ;C at 90 degrees, A at 45 degrees
ORIRESET(, 30)         ;C at $MC_TRAFO5_ROT_AX_OFFSET_1/2[0], A at 30 degrees
ORIRESET( )            ;C at $MC_TRAFO5_ROT_AX_OFFSET_1/2[0],
                       ;A at $MC_TRAFO5_ROT_AX_OFFSET_1/2[1]
2. Example of machine kinematics CAC (channel axis names C, A, B)
ORIRESET(90, 45, 90)   ;C at 90 degrees, A at 45 degrees, B at 90 degrees
ORIRESET( )            ;C at $MC_TRAFO5_ROT_AX_OFFSET_1/2[0],
                       ;A at $MC_TRAFO5_ROT_AX_OFFSET_1/2[1],
                       ;B at $MC_TRAFO5_ROT_AX_OFFSET_1/2[2]
```

Programming LEAD, TILT and THETA rotations

In respect of three- to five-axis transformation, tool orientation rotations are programmed with the LEAD and TILT angles.

In respect of a transformation with third rotary axis, additional programming settings for C2 (rotations of the orientation vector) are permitted for both orientation with vector components and with entry of the LEAD, TILT angles.

With an additional third rotary axis, the rotation of the tool about itself can be programmed with the THETA rotary angle.

6.2.4 Programming the tool orientation (A..., B..., C..., LEAD, TILT)

Function

The following options are available when programming tool orientation:

1. Direct programming the motion of rotary axes. The change of orientation always occurs in the basic or machine coordinate system. The orientation axes are traversed as synchronized axes.
2. Programming in Euler or RPY angles in accordance with angle definition using `A2, B2, C2`
3. Programming of the direction vector using `A3, B3, C3` The direction vector points from the tool tip toward the tool adapter.
4. Programming the surface normal vector at the start of the block with `A4, B4, C4` and at the end of the block with `A5, B5, C5` (face milling).
5. Programming using lead angle `LEAD` and tilt angle `TILT`
6. Programming of rotary axis of taper as normalized vector using `A6, B6, C6` or of intermediate orientation on the peripheral surface of a taper using `A7, B7, C7`,
   see "Orientation programming along the peripheral surface of a taper (ORIPLANE, ORICONxx)".
7. Programming of reorientation, direction and path length of tool during retraction movement using `A8, B8, C8`,
   see "Smoothing the orientation characteristic (ORIPATHS A8=, B8=, C8=)"

Note

In all cases, orientation programming is only permissible if an orientation transformation is active.

Advantage: These programs can be transferred to any machine kinematics.

Definition of tool orientation via G code

Note

Machine manufacturer

Machine data can be used to switch between Euler or RPY angles. If the machine data is set accordingly, changeovers are possible both depending on the active G code of group 50 and irrespective of this. The following setting options can be selected:

1. If both machine data for defining the orientation axes and defining the orientation angle are set to zero via G code:
   The angles programmed using `A2, B2, C2` are **dependent on machine data** The angle definition of orientation programming is either interpreted as Euler or RPY angles.
2. If the machine data for defining the orientation axes is set to one via G code, the changeover is **dependent** on the active G code of group 50:
   The angles programmed using `A2, B2, C2` are interpreted in accordance with the active G codes `ORIEULER, ORIRPY, ORIVIRT1, ORIVIRT2, ORIAXPOS` and `ORIPY2`. The values programmed with the orientation axes are also interpreted as orientation angles in accordance with the active G code of group 50.
3. If the machine data for defining the orientation angle is set to one via G code and the machine data for defining the orientation axes is set to zero via G code, the changeover is **not dependent** on the active G code of group 50:
   The angles programmed using `A2, B2, C2` are interpreted in accordance with one of the active G codes `ORIEULER, ORIRPY, ORIVIRT1, ORIVIRT2 ORIAXPOS` and `ORIPY2`. The values programmed with the orientation axes are always interpreted as round axis positions irrespective of the active G code of group 50.

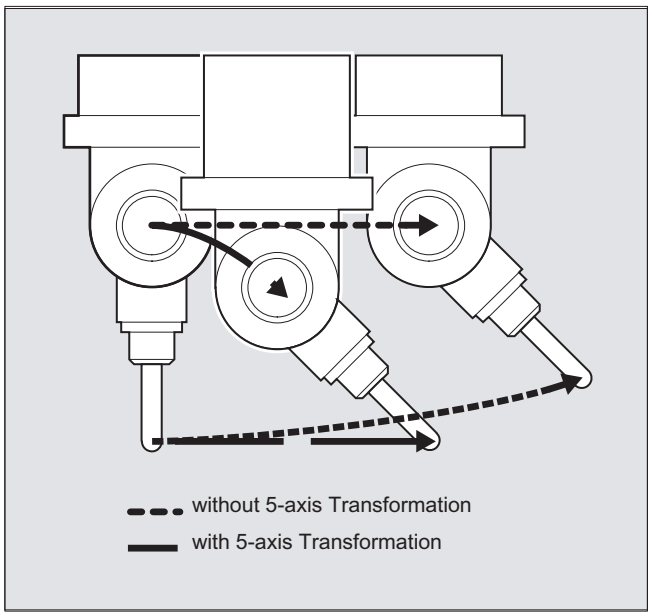
Programming

`G1 X Y Z A B C`	Programming of rotary axis motion
`G1 X Y Z A2= B2= C2=`	Programming in Euler angles
`G1 X Y Z A3== B3== C3==`	Programming of directional vector
`G1 X Y Z A4== B4== C4==`	Programming the surface normal vector at block start
`G1 X Y Z A5== B5== C5==`	Programming the surface normal vector at end of block
`LEAD=`	Lead angle for programming tool orientation
`TILT=`	Tilt angle for programming tool orientation

Parameters

G....	Details of the rotary axis motion
X Y Z	Details of the linear axes
A B C	Details of the machine axis positions of the rotary axes
A2 B2 C2	Angle programming (Euler or RPY angle) of virtual axes or orientation axes
A3 B3 C3	Details of the direction vector components
A4 B4 C4	Details, for example, for the face milling, the component of the surface normal vector at block start
A5 B5 C5	Details, for example, for the face milling, the component of the surface normal vector at block end
LEAD	Angle relative to the surface normal vector in the plane that is defined by the path tangent and the surface normal vector
TILT	Angle in the plane, perpendicular to the path tangent relative to the surface normal vector

Example: Comparison without and with 5-axis transformation



Further information

5-axis programs are usually generated by CAD/CAM systems and not entered at the controller. So the following explanations are directed mainly at programmers of postprocessors.

The type of orientation programming is defined in G code group 50:

G function	Orientation programming
ORIEULER	Via Euler angle
ORIRPY	Via RPY angle (rotation sequence ZYX)
ORIVIRT1	Via virtual orientation axes (definition 1)
ORIVIRT2	Via virtual orientation axes (definition 2)
ORIAXPOS	Via virtual orientation axes with rotary axis positions
ORIPY2	Via RPY angle (rotation sequence XYZ)

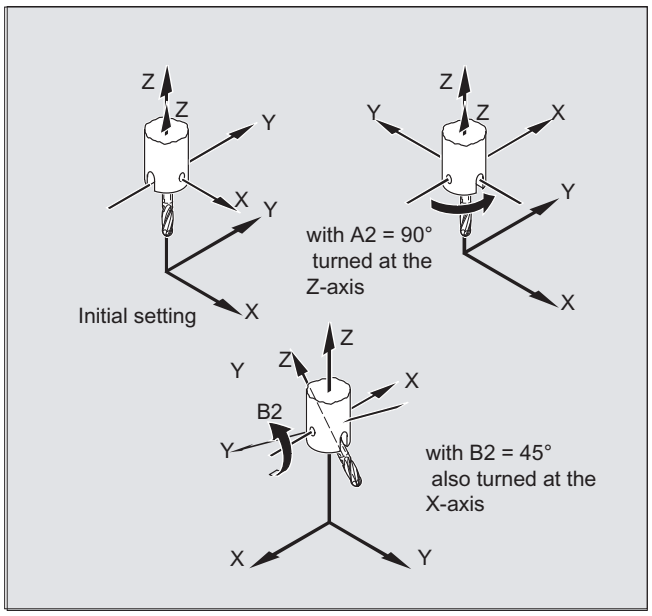
Note

The machine manufacturer can use machine data to define various variants. Please refer to the machine manufacturer's instructions.

Programming in Euler angles ORIEULER

The values programmed during orientation programming with A2, B2, C2 are interpreted as Euler angles (in degrees).

The orientation vector results from turning a vector in the Z direction firstly with A2 around the Z axis, then with B2 around the new X axis and lastly with C2 around the new Z axis.



In this case the value of C2 (rotation around the new Z axis) is meaningless and does not have to be programmed.

Programming in RPY angles ORIRPY

The values programmed with `A2, B2, C2` for orientation programming are interpreted as an RPY angle (in degrees).

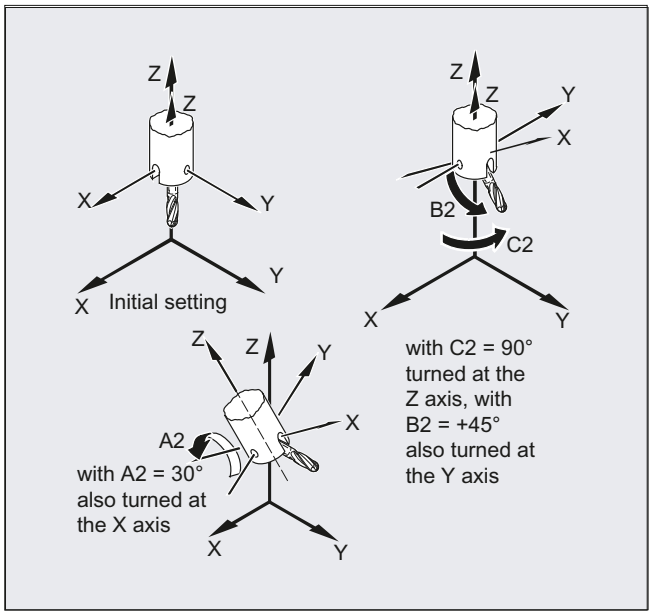
Note

In contrast to Euler angle programming, all three values here have an effect on the orientation vector.

When defining angles with orientation angle via RPY angle, the following applies for the orientation axes:

$MC_ORI_DEF_WITH_G_CODE = 0

The orientation vector results from turning a vector in the Z direction firstly with C2 around the Z axis, then with B2 around the new Y axis and lastly with A2 around the new X axis.



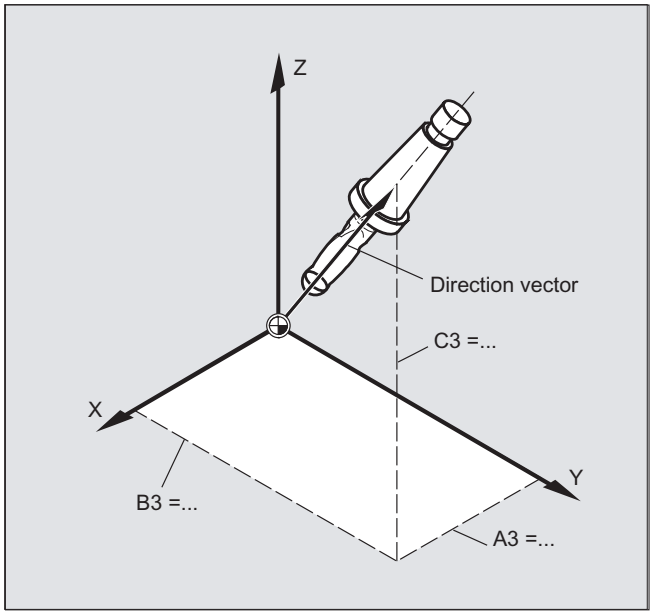
By defining the orientation axes via G code, if the machine data $MC_ORI_DEF_WITH_G_CODE = 1, then:

The orientation vector results from turning a vector in the Z direction firstly with A2 around the Z axis, then with B2 around the new Y axis and finally with C2 around the new X axis.

Programming of directional vector

The components of the direction vector are programmed with A3, B3, C3. The vector points towards the tool adapter; the length of the vector is of no significance.

Vector components that have not been programmed are set equal to zero.



Programming the tool orientation with LEAD= and TILT=

The resultant tool orientation is determined from:

- Path tangent
- Surface normal vector
  at the start of the block A4, B4, C4 and at the end of the block A5, B6, C5
- Lead angle LEAD
  in the plane defined by the path tangent and surface normal vector
- Tilt angle TILT at the end of the block
  vertical to the path tangent and relative to the surface normal vector

Behavior at inside corners (for 3D tool offset)

If the block is shortened at an inside corner, the resulting tool orientation is also achieved at the end of the block.

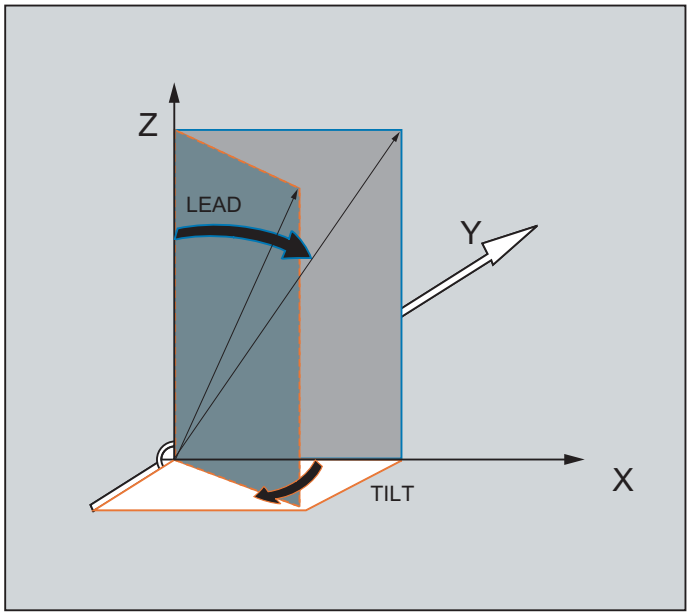
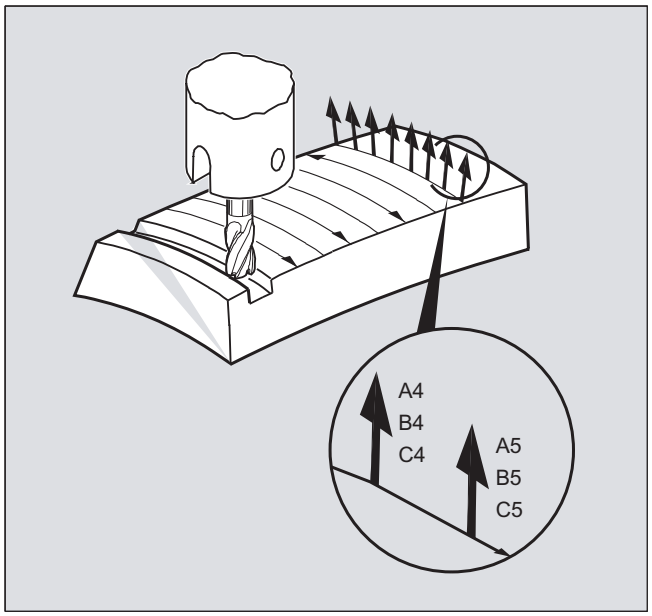


Figure 6-1 Definition of tool orientation with LEAD= and TILT=

6.2.5 Face milling (A4, B4, C4, A5, B5, C5)

Function

Face milling is used to machine curved surfaces of any kind.



For this type of 3D milling, you will require the line-by-line description of the 3D paths on the workpiece surface.

The tool shape and dimensions are taken into account in the calculations, which are normally performed in CAM. The fully calculated NC blocks are then read into the controller via postprocessors.

Programming the path curvature

Surface description

The path curvature is described by surface normal vectors with the following components:

`A4, B4, C4` Start vector at block start

`A5, B5, C5` End vector at block end

If a block only contains the start vector, the surface normal vector will remain constant throughout the block. If a block only contains the end vector, interpolation will run from the end value of the previous block via large-circle interpolation to the programmed end value.

If both start and end vectors are programmed, interpolation runs between the two directions, also via large-circle interpolation. This allows continuously smooth paths to be created.

Regardless of the active G17 to G19 level, in the initial setting, surface normal vectors point in the Z direction.

The length of a vector is meaningless.

Vector components that have not been programmed are set to zero.

When ORIWKS is active (see "Reference of the orientation axes (ORIWKS, ORIMKS): (Page 321)"), the surface normal vectors refer to the active frame and are also rotated with frame rotation.

Machine manufacturer

The surface normal vector must be perpendicular to the path tangent, within a limit value set via machine data, otherwise an alarm will be output.

6.2.6 Reference of the orientation axes (ORIWKS, ORIMKS):

Function

For orientation programming in the workpiece coordinate system using

- Euler or RPY angle or
- Orientation vector

the course of the rotary motion can be set using ORIMKS/ORIWKS.

Note

Machine manufacturer

The type of interpolation for the orientation is specified with machine data:

MD21104 $MC_ORI_IPO_WITH_G_CODE

= FALSE: The reference is provided by the G functions ORIWKS and ORIMKS.

= TRUE: The reference is provided by the G functions in the 51st group (ORIAXES, ORIVECT, ORIPLANE, etc.).

Syntax

```
ORIMKS=...
ORIWKS=...
```

Meaning

ORIMKS	Rotation in the machine coordinate system
ORIWKS	Rotation in the workpiece coordinate system

Note

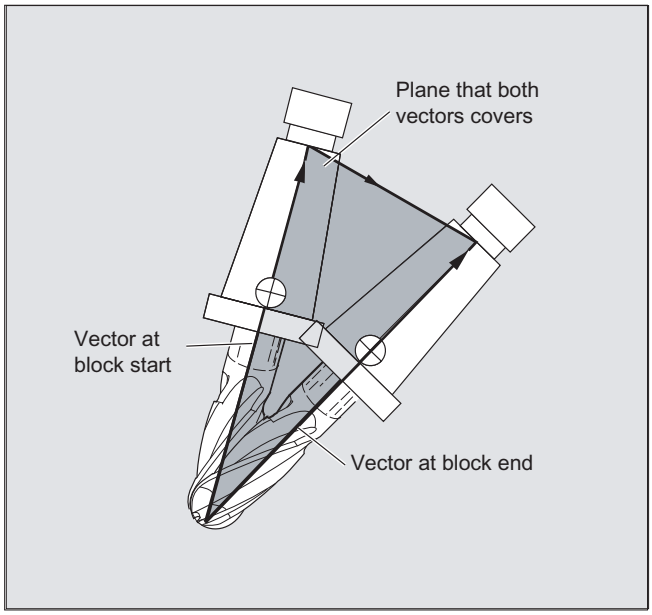
ORIWKS is the basic setting. In the case of a 5-axis program, if it is not immediately obvious on which machine it is to run, ORIWKS must always be selected. Which movements the machine actually executes depend on the machine kinematics.

ORIMKS can be used to program actual machine movements (to avoid collisions with devices or similar, for example).

Description

With ORIMKS, the movement executed by the tool **depends** on the machine kinematics. In the case of a change in orientation of a tool tip at a fixed point in space, linear interpolation takes place between the rotary axis positions.

With ORIWKS, the movement executed by the tool **does not depend** on the machine kinematics. With an orientation change with a fixed tool tip, the tool moves in the plane set up by the start and end vectors.



Singular positions

Note

ORIWKS

Orientation movements in the singular setting area of the 5-axis machine require vast movements of the machine axes. (For example, with a rotary swivel head with C as the rotary axis and A as the swivel axis, all positions with A = 0 are singular.)

Machine manufacturer

To avoid overloading the machine axes, the velocity control vastly reduces the tool path velocity near the singular positions.

With machine data

```
$MC_TRAFO5_NON_POLE_LIMIT
```

```
$MC_TRAFO5_POLE_LIMIT
```

the transformation can be parameterized in such a way that orientation movements close to the pole are put through the pole and rapid machining is possible.

Singular positions are handled only with the MD $MC_TRAFO5_POLE_LIMIT.

References:
/FB3/ Function Manual, Special Functions; 3- to 5-Axis Transformation (F2), "Singular Points and How to Deal with Them" section.

6.2.7 Programming orientation axes (ORIAXES, ORIVECT, ORIEULER, ORIRPY, ORIRPY2, ORIVIRT1, ORIVIRT2)

Function

The "Orientation axes" function describes the orientation of the tool in space and is achieved by programming the offset for the rotary axes. An additional, third degree of freedom can be achieved by also rotating the tool about itself. In this case, the tool is oriented in space via a third rotary axis for which 6-axis transformation is required. The rotation of the tool about itself is defined using the THETA angle of rotation in accordance with the type of interpolation of the rotation vectors (see "Rotations of the tool orientation (ORIROTA, ORIROTR, ORIROTT, ORIROTC, THETA) (Page 333)").

Axis identifiers A2, B2 and C2 are used to program the orientation axes.

Syntax

```
N... ORIAXES/ORIVECT                ; Linear or large-circle interpolation
N... G1 X Y Z A B C

N... ORIPLANE                       ; Orientation interpolation of the plane

N... ORIEULER/ORIRPY/ORIRPY2        : Orientation angle Euler/RPY angle
N... G1 X Y Z A2= B2= C2=           ; Angle programming of virtual axes

N... ORIVIRT1/ORIVIRT2              ; Virtual orientation axes def. 1/2
N... G1 X Y Z A3= B3= C3=           ; Direction vector programming
```

Note

Other rotary axis offsets of the orientation axes can be programmed for orientation changes along the peripheral surface of a taper in space, see "Orientation programming along the peripheral surface of a taper (ORIPLANE, ORICONCW, ORICONCCW, ORICONTO, ORICONIO) (Page 326)".

Meaning

ORIAXES:	Linear interpolation of machine or orientation axes
ORIVECT:	Large-circle interpolation (identical to ORIPLANE)
ORIMKS:	Rotation in the machine coordinate system
ORIWKS:	Rotation in the workpiece coordinate system For a description, see "Reference of the orientation axes (ORIWKS, ORIMKS): (Page 321)".
A= B= C=:	Programming the machine axis position
ORIEULER:	Orientation programming via Euler angle
ORIRPY:	Orientation programming via RPY angle The rotation sequence is XYZ and: • A2 is the angle of rotation around X • B2 is the angle of rotation around Y • C2 is the angle of rotation around Z
ORIRPY2:	Orientation programming via RPY angle The rotation sequence is ZYX and: • A2 is the angle of rotation around Z • B2 is the angle of rotation around Y • C2 is the angle of rotation around X
A2= B2= C2=:	Angle programming of virtual axes
ORIVIRT1/ORIVIRT2:	Orientation programming using virtual orientation axes Definition 1: Definition according to MD21120 $MC_ORIAX_TURN_TAB_1 Definition 2: Definition according to MD21130 $MC_ORIAX_TURN_TAB_2
A3= B3= C3=:	Direction vector programming of direction axis

Description

Machine manufacturer

MD21102 $MC_ORI_DEF_WITH_G_CODE specifies how the programmed angles A2, B2, C2 are defined:

The definition is according to MD21100 $MC_ORIENTATION_IS_EULER (standard) or the definition is according to G group 50 (ORIEULER, ORIRPY, ORIVIRT1, ORIVIRT2).

MD21104 $MC_ORI_IPO_WITH_G_CODE is used to define which interpolation mode type is active: ORIWKS/ORIMKS or ORIAXES/ORIVECT.

JOG mode

Interpolation for orientation angles in this mode of operation is always linear. During continuous and incremental traversal via the traversing keys, only one orientation axis can be traversed. Orientation axes can be traversed simultaneously using the handwheels.

For manual travel of the orientation axes, the channel-specific feed override switch or the rapid traverse override switch work at rapid traverse override.

A separate velocity setting is possible with the following machine data:

MD21160 $MC_JOG_VELO_RAPID_GEO

MD21165 $MC_JOG_VELO_GEO

MD21150 $MC_JOG_VELO_RAPID_ORI

MD21155 $MC_JOG_VELO_ORI

Note

SINUMERIK 840D sl with "handling transformation package"

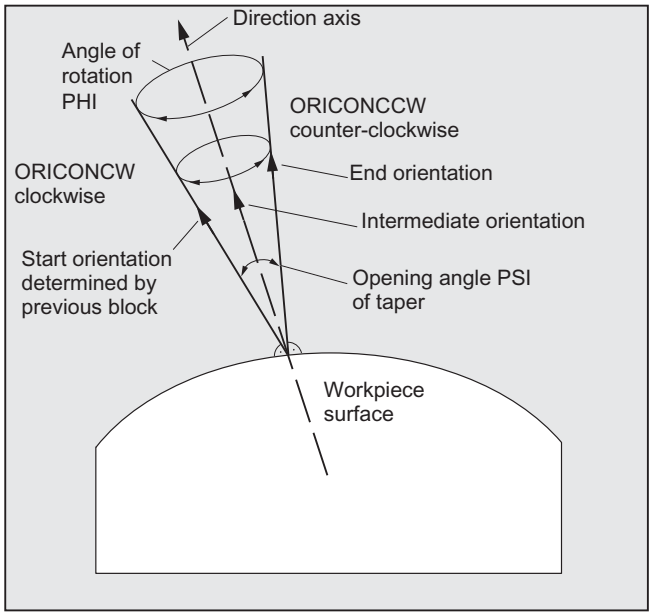
Using the "Cartesian manual traverse" function, in the JOG mode, the translation of geometry axes can be set separately from one another in the reference systems MCS, WCS and TCS.

References:
Function Manual Extended Functions; Kinematic Transformation (M1)

6.2.8 Orientation programming along the peripheral surface of a taper (ORIPLANE, ORICONCW, ORICONCCW, ORICONTO, ORICONIO)

Function

With extended orientation it is possible to execute a change in orientation along the peripheral surface of a taper in space. The orientation vector is interpolated on the peripheral surface of a taper using the ORICONxx modal command. The end orientation can be programmed with ORIPLANE for interpolation on a plane. The start orientation is usually defined by the previous blocks.



Programming

The end orientation is either defined by specifying the angle programming in the Euler or RPY angle using A2, B2, C2 or by programming the rotary axis positions using A, B, C. Further programming details are needed for orientation axes along the peripheral surface of a taper:

- Rotary axis of taper as a vector with `A6, B6, C6`
- Opening angle `PSI` with identifier `NUT`
- Intermediate orientation outside of the taper with `A7, B7, C7`

Note

Programming direction vector A6, B6, C6 for the rotary axis of the taper

The programming of an end orientation is not absolutely necessary. If no end orientation is specified, a full outside taper with 360 degrees is interpolated.

Programming the opening angle of the taper with NUT=angle

An end orientation must be specified.

A complete outside taper with 360 degrees cannot be interpolated in this way.

Programming the intermediate orientation A7, B7, C7 on the outside of the taper

An end orientation must be specified. The change in orientation and the direction of rotation is defined uniquely by the three vectors Start orientation, End orientation and Intermediate orientation. All three vectors must be different. If the programmed intermediate orientation is parallel to the start or end orientation, a linear large-circle interpolation of the orientation is executed in the plane that is defined by the start and end vector.

Extended orientation interpolation on the peripheral surface of a taper

```
N... ORICONCW or ORICONCCW
N... A6= B6= C6= A3= B3= C3=
or
N... ORICONTO
N... G1 X Y Z A6= B6= C6=
or
N... ORICONIO
N... G1 X Y Z A7= B7= C7=
N... PO[PHI]=(a2, a3, a4, a5)
N... PO[PSI]=(b2, b3, b4, b5)
```

Interpolation on the outside of a taper with

direction vector in the clockwise/counter-clockwise direction of the taper and end orientation or

tangential transition and specification of end orientation

or

specification of end orientation and intermediate orientation on the outside of the taper with

polynomials for angle of rotation and polynomials for opening angle

Parameters

ORIPLANE	Interpolation in the plane (large-circle interpolation)
ORICONCW	Interpolation on the peripheral surface of a taper in the clockwise direction
ORICONCCW	Interpolation on the peripheral surface of a taper in the counter-clockwise direction
ORICONTO	Interpolation on the peripheral surface of a taper with tangential transition
A6= B6= C6=	Programming of a rotary axis of the taper (normalized vector)
NUT=angle	Opening angle of taper in degrees
NUT=+179	Traverse angle smaller than or equal to 180 degrees
NUT=-181	Traverse angle greater than or equal to 180 degrees

ORICONIO	Interpolation on the peripheral surface of a taper
A7= B7= C7=	Intermediate orientation (programming as normalized vector)
PHI	Angle of rotation of the orientation about the direction axis of the taper
PSI	Opening angle of the taper
Possible polynomials PO[PHI]=(a2, a3, a4, a5) PO[PSI]=(b2, b3, b4, b5)	Apart from the different angles, polynomials can also be programmed up to the 5th degree

Example: Different changes to orientation

```
Program code                                Comment
…
N10 G1 X0 Y0 F5000
N20 TRAORI(1)                               ; Orientation transformation on.
N30 ORIVECT                                 ; Interpolate tool orientation as a
                                              vector.
…                                           ; Tool orientation in the plane.
N40 ORIPLANE                                ; Select large-circle interpolation.
N50 A3=0 B3=0 C3=1
N60 A3=0 B3=1 C3=1                          ; Orientation in the Y/Z plane is rotated
                                              through 45 degrees, orientation
                                              (0,1/√2,1/√2) is reached at the end of
                                              the block.
…
N70 ORICONCW                                ; Orientation programming on the outside
                                              of the taper:
N80 A6=0 B6=0 C6=1 A3=0 B3=0 C3=1           ; The orientation vector is interpolated
                                              on the outside of a taper with the
                                              direction (0,0,1) up to the orientation
                                              (1/√2,0,1/√2) in the clockwise sense,
                                              the angle of rotation is 270 degrees.
N90 A6=0 B6=0 C6=1                          ; The tool orientation goes through a
                                              full revolution on the outside of the
                                              same taper.
```

Description

If changes of orientation along the peripheral surface of a taper anywhere in space are to be described, the vector about which the tool orientation is to be rotated must be known. The start and end orientation must also be specified. The start orientation results from the previous block and the end orientation has to be programmed or defined via other conditions.

Programming in the ORIPLANE plane corresponds to ORIVECT

The programming of large-radius circular interpolation together with angle polynomials corresponds to the linear and polynomial interpolation of contours. The tool orientation is interpolated in a plane that is defined by the start and end orientation. If additional polynomials are programmed, the orientation vector can also be tilted out of the plane.

Programming of circles in a plane G2/G3, CIP and CT

The extended orientation corresponds to the interpolation of circles in a plane. For the corresponding programming options for circles with centers or radii such as G2/G3, circle via intermediate point CIP and tangential circles CT, see

References: Programming Manual Fundamentals, "Programming motion commands".

Orientation programming

Interpolation of the orientation vector on the peripheral surface of a taper ORICONxx

Four different types of interpolation from G-code group 51 can be selected for interpolating orientations on the peripheral surface of a taper:

1. Interpolation on the outside of a taper in the clockwise direction `ORICONCW` with specification of end orientation and taper direction, or opening angle. The direction vector is programmed with identifiers `A6, B6, C6` and the opening angle of the taper with identifier NUT= value range in interval 0 degrees to 180 degrees.
2. Interpolation on the outside of a taper in the counterclockwise direction `ORICONCCW` with specification of end orientation and taper direction, or opening angle. The direction vector is programmed with identifiers `A6, B6, C6` and the opening angle of the taper with identifier NUT= value range in interval 0 degrees to 180 degrees.
3. Interpolation on the outside of a taper `ORICONIO` with specification of end orientation and an intermediate orientation, which is programmed with identifiers `A7, B7, C7`.
4. Interpolation on the outside of a taper `ORICONTO` with tangential transition and specification of end orientation. The direction vector is programmed with identifiers `A6, B6, C6`.

6.2.9 Specification of orientation for two contact points (ORICURVE, PO[XH]=, PO[YH]=, PO[ZH]=)

Function

Programming the change in orientation using the second curve in space ORICURVE

Another way to program changes in orientation, besides using the tool tip along a curve in space, is to program the motion of a second contact point of the tool using `ORICURVE`. In this way, changes in tool orientation can be defined uniquely, as when programming the tool vector itself.

Machine manufacturer

Please refer to the machine manufacturer's notes on axis identifiers that can be set via machine data for programming the second orientation path of the tool.

Programming

This type of interpolation can be used to program points (using G1) or polynomials (using POLY) for the two curves in space. Circles and involutes are not permitted. A BSPLINE spline interpolation and the "Combine short spline blocks" function can also be activated.

References:
Function Manual, Basic Functions; Continuous-Path Mode, Exact Stop, Look Ahead (B1), Section: Combine short spline blocks

The other spline types, ASPLINE and CSPLINE, and compressor activation using COMPON, COMPCURV or COMPCAD are not permitted.

The motion of the two contact points of the tool can be predefined up to the 5th degree when programming the orientation polynomials for coordinates.

Extended orientation interpolation with additional curve in space and polynomials for coordinates

```
N... ORICURVE
N... PO[XH]=(xe, x2, x3, x4, x5)
N... PO[YH]=(ye, y2, y3, y4, y5)
N... PO[ZH]=(ze, z2, z3, z4, z5)
```

Specification of the motion of the second contact point of the tool and additional polynomials of the coordinates in question

Parameters

ORICURVE	Interpolation of the orientation specifying a movement between two contact points of the tool.
XH YH ZH	Identifiers of the coordinates of the second contact point of the tool of the additional contour as a curve in space
Possible polynomials PO[XH]=(xe, x2, x3, x4, x5) PO[YH]=(ye, y2, y3, y4, y5) PO[ZH]=(ze, z2, z3, z4, z5)	Apart from using the appropriate end points, the curves in space can also be programmed using polynomials.
xe, ye, ze	End points of the curve in space
xi, yi, zi	Coefficients of the polynomials up to the 5th degree

Note

Identifiers XH YH ZH for programming a second orientation path

The identifiers must be selected such that no conflict arises with the other identifiers or linear axes

X Y Z axes

and rotary axes such as

A2 B2 C2 Euler angle or RPY angle

A3 B3 C3 direction vectors

A4 B4 C4 or A5 B5 C5 surface normal vectors

A6 B6 C6 rotation vectors or A7 B7 C7 intermediate point coordinates

or other interpolation parameters.

6.3 Orientation polynomials (PO[angle], PO[coordinate])

Function

Irrespective of the polynomial interpolation from G-code group 1 that is currently active, two different types of orientation polynomial can be programmed up to the 5th degree for a 3-axis to 5-axis transformation.

1. Polynomials for **angles:** lead angle LEAD, tilt angle TILT
   in relation to the plane that is defined by the start and end orientation.
2. Polynomials for **coordinates:** XH, YH, ZH of the second curve in space for the tool orientation of a reference point on the tool.

With a 6-axis transformation, the rotation of rotation vector THT can be programmed with polynomials up to the 5th degree for rotations of the tool itself, in addition to the tool orientation.

Syntax

Type 1 orientation polynomials for **angles**

```
N… PO[PHI]=(a2, a3, a4, a5)
N… PO[PSI]=(b2, b3, b4, b5)
```

3-axis to 5-axis transformation

Type 2 orientation polynomials for **coordinates**

```
N… PO[XH]=(xe, x2, x3, x4, x5)
N… PO[YH]=(ye, y2, y3, y4, y5)
N… PO[ZH]=(ze, z2, z3, z4, z5)
```

Identifiers for the coordinates of the second orientation path for tool orientation

In both cases, with 6-axis transformations, a polynomial can also be programmed for the **rotation** using

```
N… PO[THT]=(c2, c3, c4, c5)
```

or

```
N… PO[THT]=(d2, d3, d4, d5)
```

Interpolation of the rotation relative to the path

Interpolation absolute, relative and tangential to the change of orientation

of the orientation vector. This is possible if the transformation supports a rotation vector with an offset that can be programmed and interpolated using the THETA angle of rotation.

Meaning

`PO[PHI]`	Angle in the plane between start and end orientation
`PO[PSI]`	Angle describing the tilt of the orientation from the plane between start and end orientation
`PO[THT]`	Angle of rotation created by rotating the rotation vector of one of the G codes of group 54 that is programmed using THETA
`PHI`	Lead angle LEAD
`PSI`	Tilt angle TILT
`THETA`	Rotation about the tool direction in Z
`PO[XH]`	X coordinate of the reference point on the tool
`PO[YH]`	Y coordinate of the reference point on the tool
`PO[ZH]`	Z coordinate of the reference point on the tool

Description

Orientation polynomials cannot be programmed:

- If ASPLINE, BSPLINE, CSPLINE spline interpolations are active.
  Type 1 polynomials for orientation angles are possible for every type of interpolation except spline interpolation, that is, linear interpolation with rapid traverse G00 or with feedrate G01
  with polynomial interpolation using POLY and
  circular/involute interpolation G02, G03, CIP, CT, INVCW and INCCCW
  .
  However, type 2 polynomials for orientation coordinates are only possible if
  linear interpolation with rapid traverse G00 or with feedrate G01 or
  polynomial interpolation with POLY is active.
- If the orientation is interpolated using ORIAXES axis interpolation. In this case, polynomials can be programmed directly with PO[A] and PO[B] for orientation axes A and B.

Type 1 orientation polynomials with ORIVECT, ORIPLANE and ORICONxx

Only type 1 orientation polynomials are possible for large-radius circular interpolation and interpolation outside of the taper with ORIVECT, ORIPLANE and ORICONxx.

Type 2 orientation polynomials with ORICURVE

If interpolation with the additional curve in space ORICURVE is active, the Cartesian components of the orientation vector are interpolated and only type 2 orientation polynomials are possible.

6.4 Rotations of the tool orientation (ORIROTA, ORIROTR, ORIROTT, ORIROTC, THETA)

Function

If you also want to be able to change the orientation of the tools on machine types with movable tools, program each block with end orientation. Depending on the machine kinematics you can either program the orientation direction of the orientation axes or the direction of rotation of orientation vector THETA. Different interpolation types can be programmed for these rotation vectors:

- ORIROTA: Angle of rotation to an absolute direction of rotation.
- ORIROTR: Angle of rotation relative to the plane between the start and end orientation.
- ORIROTT: Angle of rotation relative to the change in the orientation vector.
- ORIROTC: Tangential angle of rotation to the path tangent.

Syntax

Only if interpolation type ORIROTA is active can the angle of rotation or rotation vector be programmed in all four modes as follows:

1. Directly as rotary axis positions `A, B, C`
2. Euler angles (in degrees) with `A2, B2, C2`
3. RPY angles (in degrees) with `A2, B2, C2`
4. Direction vector via `A3, B3, C3` (angle of rotation using `THETA=<value>`)

If ORIOTR or ORIOTT is active, the angle of rotation can only be programmed directly with `THETA`.

A rotation can also be programmed in a separate block without an orientation change taking place. In this case, ORIROTR and ORIROTT are irrelevant. In this case, the angle of rotation is always interpreted with reference to the absolute direction (ORIROTA).

`N... ORIROTA`
`N... ORIROTR`
`N... ORIROTT`
`N... ORIROTC`
	Define the interpolation of the rotation vector

`N... A3= B3= C3= THETA=<value>`	Define the rotation of the orientation vector
`N... PO[THT]=(d2, d3, d4, d5)`	Interpolate angle of rotation with a 5th order polynomial

Meaning

`ORIROTA`:	Angle of rotation to an absolute direction of rotation
`ORIROTR`:	Angle of rotation relative to the plane between the start and end orientation
`ORIROTT`:	Angle of rotation as a tangential rotation vector to the change of orientation
`ORIROTC`:	Angle of rotation as a tangential rotation vector to the path tangent
`THETA`:	Rotation of the orientation vector
`THETA=<value>`:	Angle of rotation in degrees reached by the end of the block
`THETA=Θe`:	Angle of rotation with end angle Θ_e of rotation vector
`THETA=AC(…)`:	Non-modal switchover to absolute dimensions
`THETA=AC(…)`:	Non-modal switchover to incremental dimensions
`Θe`:	End angle of rotational vector both absolute with G90 and relative with G91 (incremental dimensioning) is active
`PO[THT]=(....)`:	Polynomial for angle of rotation

Example: Rotations of the orientations

```
Program code                              Comment
N10 TRAORI                                ; Activate orientation transformation
N20 G1 X0 Y0 Z0 F5000                     ; Tool orientation
N30 A3=0 B3=0 C3=1 THETA=0                ; In Z direction with angle of rotation 0
N40 A3=1 B3=0 C3=0 THETA=90               ; In X direction and rotation about 90 degrees
N50 A3=0 B3=1 C3=0 PO[THT]=(180,90)       ; Orientation
N60 A3=0 B3=1 C3=0 THETA=IC(-90)          ; In Y direction and rotation about 180
                                            degrees
N70 ORIROTT                               ; Remains constant and rotation to 90 degrees
N80 A3=1 B3=0 C3=0 THETA=30               ; Angle of rotation relative to change of
                                            orientation
                                          ; Rotation vector in angle 30 degrees to X/Y
                                            plane
```

When interpolating block N40, the angle of rotation from initial value of 0 degrees to final value of 90 degrees is interpolated linearly. In block N50, the angle of rotation changes from 90 degrees to 180 degrees, according to parabola θ(u) = +90u2. In N60, a rotation can also be executed without a change in orientation taking place.

With N80, the tool orientation is rotated from the Y direction toward the X direction. The change in orientation takes place in the X/Y plane and the rotation vector describes an angle of 30 degrees to this plane.

Description

ORIROTA

The angle of rotation THETA is interpolated with reference to an absolute direction in space. The basic direction of rotation is defined in the machine data.

ORIROTR

The angle of rotation THETA is interpreted relative to the plane defined by the start and end orientation.

ORIROTT

The angle of rotation THETA is interpreted relative to the change in orientation. For THETA=0 the rotation vector is interpolated tangentially to the change in orientation and only differs from ORIROTR if at least one polynomial has been programmed for "tilt angle PSI" for the orientation. The result is a change in orientation that is not executed in the plane. An additional angle of rotation THETA can then be used to interpolate the rotation vector such that it always produces a specific value referred to the change in orientation.

ORIROTC

The rotation vector is interpolated relative to the path tangent with an offset that can be programmed using the THETA angle. A polynomial PO[THT]=(c2, c3, c4, c5) up to the 5th degree can also be programmed for the offset angle.

6.5 Orientations relative to the path

6.5.1 Orientation types relative to the path

Function

By using this expanded function, relative orientation is not only achieved at the end of the block, but across the entire trajectory. The orientation achieved in the previous block is transferred to the programmed end orientation using large-circle interpolation. There are basically two ways of programming the desired orientation relative to the path:

1. Like the tool rotation, the tool orientation is interpolated relative to the path using ORIPATH, ORPATHTS.
2. The orientation vector is programmed and interpolated in the usual manner. The rotation of the orientation vector is initiated relative to the path tangent using ORIROTC.

Syntax

The type of interpolation of the orientation and the rotation of the tool is programmed using:

`N... ORIPATH`	Orientation relative to the path
`N... ORIPATHS`	Orientation relative to the path with smoothing of orientation characteristic
`N... ORIROTC`	Interpolation of the rotation vector relative to the path

An orientation blip caused by a corner on the trajectory can be smoothed using `ORIPATHS`. The direction and path length of the retracting movement is programmed via the vector using the components `A8=X, B8=Y C8=Z`.

`ORIPATH/ORIPATHS` can be used to program various references to the path tangent via the three angles

- `LEAD=` Specification of lead angle relative to the path and surface
- `TILT=` Specification of tilt angle relative to the path and surface
- `THETA=` Angle of rotation

for the entire trajectory. Polynomials up to the 5th degree can be programmed in addition to the `THETA` angle of rotation using `PO[THT]=(...)`.

Note

Machine manufacturer

Please refer to the machine manufacturer's instructions. Other settings can be made for orientations relative to the path via configurable machine and setting data. For more detailed information, please refer to

References:
/FB3/ Function Manual, Special Functions; 3 to 5-Axis Transformation (F2),
Section "Orientation"

Meaning

Various settings can be made for the interpolation of angles LEAD and TILT via machine data:

- The tool-orientation reference programmed using LEAD and TILT is retained for the entire block.
- Lead angle LEAD: rotation about the direction vertical to the tangent and normal vector TILT: rotation of the orientation about the normal vector.
- Lead angle LEAD: rotation about the direction vertical to the tangent and normal vector Tilt angle TILT: rotation of the orientation in the direction of the path tangent.
- Angle of rotation THETA: rotation of the tool about itself with an additional third rotary axis acting as an orientation axis in 6-axis transformation.

Note

Orientation relative to the path not permitted in conjunction with OSC, OSS, OSSE, OSD and OST

Orientation interpolation relative to the path, that is ORIPATH or ORIPATHS and ORIOTC, cannot be programmed in conjunction with orientation characteristic smoothing with a G code from group 34. OSOF has to be active for this.

6.5.2 Rotation of the tool orientation relative to the path (ORIPATH, ORIPATHS, angle of rotation)

Function

With a 6-axis transformation, the tool can be rotated about itself with a third rotary axis to orientate the tool as desired in space. With a rotation of the tool orientation relative to the path using ORIPATH or ORIPATHS, the additional rotation can be programmed via the THETA angle of rotation. Alternatively, the LEAD and TILT angles can be programmed using a vector, which is located in the plane vertical to the tool direction.

Machine manufacturer

Please refer to the machine manufacturer's instructions. The interpolation of the LEAD and TILT angles can be set differently using machine data.

Syntax

Rotation of tool orientation and tool

The type of tool orientation relative to the path is activated using ORIPATH or ORIPATHS.

`N... ORIPATH`	Activate type of orientation relative to the path
`N... ORIPATHS`	Activate type of orientation relative to the path with smoothing of the orientation characteristic

Activating the three angles that can be rotated:

`N... LEAD=`	Angle for the programmed orientation relative to the surface normal vector
`N... TILT=`	Angle for the programmed orientation in the plane, vertical to the path tangent relative to the surface normal vector
`N... THETA=`	Angle of rotation relative to the change of orientation in the tool direction of the third rotary axis

The values of the angles at the end of block are programmed using `LEAD=value`, `TILT=value` or `THETA=value`. In addition to the constant angles, polynomials can be programmed for all three angles up to the 5th degree.

`N... PO[PHI]=(a2, a3, a4, a5)`	Polynomial for the leading angle LEAD
`N... PO[PSI]=(b2, b3, b4, b5)`	Polynomial for the tilt angle TILT
`N... PO[THT]=(d2, d3, d4, d5)`	Polynomial for the angle of rotation THETA

The higher polynomial coefficients, which are zero, can be omitted when programming. Example: `PO[PHI]=a2` results in a parabola for the `LEAD` angle.

Meaning

Tool orientation relative to the path

`ORIPATH`	Tool orientation in relation to path
`ORIPATHS`	Tool orientation in relation to path, blips in the orientation characteristic are smoothed
`LEAD`	Angle relative to the surface normal vector in the plane that is defined by the path tangent and the surface normal vector
`TILT`	Rotation of orientation in the Z direction or rotation about the path tangent
`THETA`	Rotation about the tool direction toward Z
`PO[PHI]`	Orientation polynomial for the LEAD angle
`PO[PSI]`	Orientation polynomial for the TILT angle
`PO[THT]`	Orientation polynomial for the THETA angle of rotation

Note

Angle of rotation THETA

A 6-axis transformation is required to rotate a tool with a third rotary axis that acts as an orientation axis about itself.

6.5.3 Interpolation of the tool rotation relative to the path (ORIROTC, THETA)

Function

Interpolation with rotation vectors

The rotation vector of the tool rotation, programmed with ORIROTC, relative to the path tangent can also be interpolated with an offset that can be programmed using the THETA angle of rotation. A polynomial can, therefore, be programmed up to the 5th degree for the offset angle using PO[THT].

Syntax

`N... ORIROTC`	Initiate the rotation of the tool relative to the path tangent
`N... A3= B3= C3= THETA=value`	Define the rotation of the orientation vector
`N... A3= B3= C3= PO[THT]=(c2, c3, c4, c5)`	Interpolate offset angle with polynomial up to 5th degree

A rotation can also be programmed in a separate block without an orientation change taking place.

Meaning

Interpolation of the rotation of tool relative to the path in 6-axis transformation

`ORIROTC`	Initiate tangential rotation vector relative to path tangent
`THETA=value`	Angle of rotation in degrees reached by the end of the block
`THETA=θe`	Angle of rotation with end angle Θ_e of rotation vector
`THETA=AC(…)`	Non-modal switchover to absolute dimensions
`THETA=IC(…)`	Non-modal switchover to incremental dimensions
`PO[THT]=(c2, c3, c4, c5)`	Interpolate offset angle with polynomial of 5th degree

Note

Interpolation of the rotation vector ORIROTC

Initiating rotation of the tool relative to the path tangent in the opposite direction to the tool orientation, is only possible with a 6-axis transformation.

With active ORIROTC

Rotation vector ORIROTA cannot be programmed. If programming is undertaken, ALARM 14128 "Absolute programming of tool rotation with active ORIROTC" is output.

Orientation direction of the tool for 3-axis to 5-axis transformation

The orientation direction of the tool can be programmed via Euler angles, RPY angles or direction vectors as with 3-axis to 5-axis transformations. Orientation changes of the tool in space can also be achieved by programming the large-circle interpolation ORIVECT, linear interpolation of the orientation axes ORIAXES, all interpolations on the peripheral surface of a taper ORICONxx, and interpolation in addition to the curve in space with two contact points of the tool ORICURVE.

`G....`	Details of the rotary axis motion
`X Y Z`	Details of the linear axes
`ORIAXES`	Linear interpolation of machine or orientation axes
`ORIVECT`	Large-circle interpolation (identical to ORIPLANE)
`ORIMKS`	Rotation in the machine coordinate system
`ORIWKS`	Rotation in the workpiece coordinate system
	Description, see the Rotations of the tool orientation section
`A= B= C=`	Programming the machine axis position
`ORIEULER`	Orientation programming via Euler angle
`ORIRPY`	Orientation programming via RPY angle
`A2= B2= C2=`	Angle programming of virtual axes
`ORIVIRT1`	Orientation programming using virtual orientation axes
`ORIVIRT2`	(definition 1), definition according to MD $MC_ORIAX_TURN_TAB_1
	(definition 2), definition according to MD $MC_ORIAX_TURN_TAB_2
`A3= B3= C3=`	Direction vector programming of direction axis
`ORIPLANE`	Interpolation in the plane (large-circle interpolation)
`ORICONCW`	Interpolation on the peripheral surface of a taper in the clockwise direction
`ORICONCCW`	Interpolation on the peripheral surface of a taper in the counter-clockwise direction
`ORICONTO`	Interpolation on the peripheral surface of a taper with tangential transition
`A6= B6= C6=`	Programming of a rotary axis of the taper (normalized vector)
`NUT=angle`	Opening angle of taper in degrees
`NUT=+179`	Traverse angle smaller than or equal to 180 degrees
`NUT=-181`	Traverse angle greater than or equal to 180 degrees
`ORICONIO`	Interpolation on the peripheral surface of a taper
`A7= B7= C7=`	Intermediate orientation (programming as normalized vector)
`ORICURVE XH YH ZH, e.g. with polynomials PO[XH]=(xe, x2, x3, x4, x5)`	Interpolation of the orientation specifying a movement between two contact points of the tool. In addition to the end points, additional curve polynomials can also be programmed.

Note

If the tool orientation with active ORIAXES is interpolated via the orientation axes, the angle of rotation is only initiated relative to the path at the end of block.

6.5.4 Smoothing of orientation characteristic (ORIPATHS A8=, B8=, C8=)

Function

Changes of orientation that take place with constant acceleration on the contour can cause unwanted interruptions to the path motions, particularly at the corner of a contour. The resulting blip in the orientation characteristic can be smoothed by inserting a separate intermediate block. If ORIPATHS is active during reorientation, the change in orientation occurs at a constant acceleration. The tool can be retracted in this phase.

Machine manufacturer

Please refer to the machine manufacturer's notes on any predefined machine and setting data used to activate this function.

Machine data can be used to set how the retracting vector is interpreted:

1. In the TCS, the Z coordinate is defined by the tool direction.
2. In the WCS, the Z coordinate is defined by the active plane.

For further explanations about the "Orientation relative to the path" function, see
References:
Function Manual, Special Functions; Multi-axis Transformations (F2)

Syntax

Further programming details are needed at the corner of the contour for constant tool orientations relative to the path as a whole. The direction and path length of this motion is programmed via the vector using the components A8=X, B8=Y C8=Z.

```
N... ORIPATHS A8=X B8=Y C8=Z
```

Meaning

`ORIPATHS`	Tool orientation relative to the path; blip in orientation characteristic is smoothed
`A8= B8= C8=`	Vector components for direction and path length
`X, Y, Z`	Retracting movement in tool direction

Note

Programming direction vectors A8, B8, C8

If the length of this vector is exactly zero, no retracting movement is executed.

ORIPATHS

Tool orientation relative to the path is activated using ORIPATHS. The orientation is otherwise transferred from the start orientation to the end orientation by means of linear large-circle interpolation.

6.6 Compression of the orientation (COMPON, COMPCURV, COMPCAD)

Function

NC programs, in which orientation transformation (TRAORI) is active and tool orientations are programmed (no matter what type), can be compressed if kept within specified limits.

Programming

Tool orientation

If orientation transformation (TRAORI) is active, for 5-axis machines, tool orientation can be programmed in the following way (independent of the kinematics):

- Programming of the direction **vectors** via:

```
A3=<...> B3=<...> C3=<...>
```

- Programming of the Euler**angles** or RPY-**angles** via:

```
A2=<...> B2=<...> C2=<...>
```

Rotation of the tool

For **6-axis** machines you can program the tool rotation in addition to the tool orientation.

The angle of rotation is programmed with:

```
THETA=<...>
```

See "Rotation of tool orientation (Page 333)".

Note

NC blocks in which additional rotation is programmed, can only be compressed if the angle of rotation changes **linearly**, meaning that a polynomial with PO[THT]=(...) for the angle of rotation should not be programmed.

General structure of an NC block that can be compressed

The general structure of an NC block that can be compressed can therefore look like this:

```
N... X=<...> Y=<...> Z=<...> A3=<...> B3=<...> C3=<...> THETA=<...> F=<...>
```

or

```
N... X=<...> Y=<...> Z=<...> A2=<...> B2=<...> C2=<...> THETA=<...> F=<...>
```

Note

The position values can be entered directly (e.g. X90) or indirectly via parameter settings (e.g. X=R1*(R2+R3)).

Programming tool orientation using rotary axis positions

Tool orientation can be also specified using rotary axis positions, e.g. with the following structure:

```
N... X=<...> Y=<...> Z=<...> A=<...> B=<...> C=<...> THETA=<...> F=<...>
```

In this case, compression is executed in two different ways, dependent on whether large radius circular interpolation is executed. If no large radius circular interpolation takes place, then the compressed change in orientation is represented in the usual way by axial polynomials for the rotary axes.

Contour accuracy

Depending on the selected compression mode (MD20482 $MC_COMPRESSOR_MODE) either the configured axis-specific tolerances (MD33100 $MA_COMPRESS_POS_TOL) or the following channel-specific tolerances – set using setting data – are effective for the geometry axes and orientation axes for compression:

SD42475 $SC_COMPRESS_CONTUR_TOL (maximum contour deviation)

SD42476 $SC_COMPRESS_ORI_TOL (maximum angular deviation for tool orientation)

SD42477 $SC_COMPRESS_ORI_ROT_TOL (maximum angular deviation for the angle of rotation of the tool) (only available on 6-axis machines)

References:
Function Manual Basic Functions; 3 to 5-Axis Transformation (F2),
Section: "Compression of the orientation"

Activation/deactivation

Compressor functions are activated using the modal G codes `COMPON`, `COMPCURV` or `COMPCAD`.

`COMPOF` terminates the compressor function.

See "NC block compression (COMPON, COMPCURV, COMPCAD) (Page 241)".

Note

Orientation motion is only compressed when large radius circular interpolation is active (i.e. tool orientation is changed in the plane which is determined by start and end orientation).

Large radius circular interpolation is executed under the following conditions:

- MD21104 $MC_ORI_IPO_WITH_G_CODE = 0,
  ORIWKS is active and
  the orientation is programmed as a vector (with A3, B3, C3 or A2, B2, C2).
- MD21104 $MC_ORI_IPO_WITH_G_CODE = 1 and
  ORIVECT or ORIPLANE is active.

  The tool orientation can be programmed either as a direction vector or with rotary axis positions. If one of the G-codes `ORICONxx` or `ORICURVE` is active, or if polynomials for the orientation angles (`PO[PHI]` and `PO[PSI]`) are programmed, no large circle interpolation will be executed.

Example

In the example program below, a circle approached by a polygon definition is compressed. The tool orientation moves on the outside of the taper at the same time. Although the programmed orientation changes are executed one after the other, but in an unsteady way, the compressor function generates a smooth motion of the orientation.

```
Programming                                Comment
DEF INT NUMBER=60
DEF REAL RADIUS=20
DEF INT COUNTER
DEF REAL ANGLE
N10 G1 X0 Y0 F5000 G64

$SC_COMPRESS_CONTUR_TOL=0.05               ; Maximum deviation of the contour = 0.05 mm
$SC_COMPRESS_ORI_TOL=5                     ; Maximum deviation of the orientation
                                             = 5 degrees

TRAORI
COMPCURV
                                           ; The movement describes a circle generated
                                             from polygons. The orientation moves on a
                                             taper around the Z axis with an opening
                                             angle of 45 degrees.
N100 X0 Y0 A3=0 B3=-1 C3=1
N110 FOR COUNTER=0 TO NUMBER
N120 ANGLE=360*COUNTER/NUMBER
N130 X=RADIUS*cos(angle) Y=RADIUS*sin(angle)
A3=sin(angle) B3=-cos(angle) C3=1
N140 ENDFOR
```

6.7 Smoothing the orientation characteristic (ORISON, ORISOF)

Function

The "Smoothing the orientation characteristic (ORISON)" function can be used to smooth oscillations affecting orientation over several blocks. The aim is to achieve a smooth characteristic for both the orientation and the contour.

Requirement

The "Smoothing the orientation characteristic (ORISON)" function is only available in systems with 5-/6-axis transformation.

Syntax

```
ORISON
...
ORISOF
```

Meaning

ORISON:	Smoothing of the orientation characteristic ON
	Effective: Modal
ORISOF:	Smoothing of the orientation characteristic OFF
	Effective: Modal

Setting data

The orientation characteristic is smoothed conforming to:

- A predefined maximum tolerance (maximum angular deviation of the tool orientation in degrees)

  and

- A predefined maximum path distance

These specifications are defined in setting data:

- SD42678 $SC_ORISON_TOL (tolerance for smoothing the orientation characteristic)
- SD42680 O$SC_ORISON_DIST (path distance for smoothing the orientation characteristic)

Example

```
Program code                    Comment
...
TRAORI()                        ; Activation of orientation transformation.
ORISON                          ; Activation of orientation smoothing.
$SC_ORISON_TOL=1.0              ; Orientation tolerance smoothing = 1.0 degrees.
G91
X10 A3=1 B3=0 C3=1
X10 A3=-1 B3=0 C3=1
X10 A3=1 B3=0 C3=1
X10 A3=-1 B3=0 C3=1
X10 A3=1 B3=0 C3=1
X10 A3=-1 B3=0 C3=1
X10 A3=1 B3=0 C3=1
```

```
Program code                        Comment
X10 A3=-1 B3=0 C3=1
X10 A3=1 B3=0 C3=1
X10 A3=-1 B3=0 C3=1
...
ORISOF                              ; Deactivation of orientation smoothing.
...
```

The orientation is pivoted through 90 degrees on the XZ plane from -45 to +45 degrees. Due to the smoothing of the orientation characteristic the orientation is no longer able to reach the maximum angle values of -45 or +45 degrees.

Further information

Number of blocks

The orientation characteristic is smoothed over a configured number of blocks set in machine data MD28590 $MC_MM_ORISON_BLOCKS.

Note

If smoothing of the orientation characteristic is activated with `ORISON` without sufficient block memory having been configured for it (MD28590 < 4), an alarm signal will be output and the function cannot be executed.

Maximum block path length

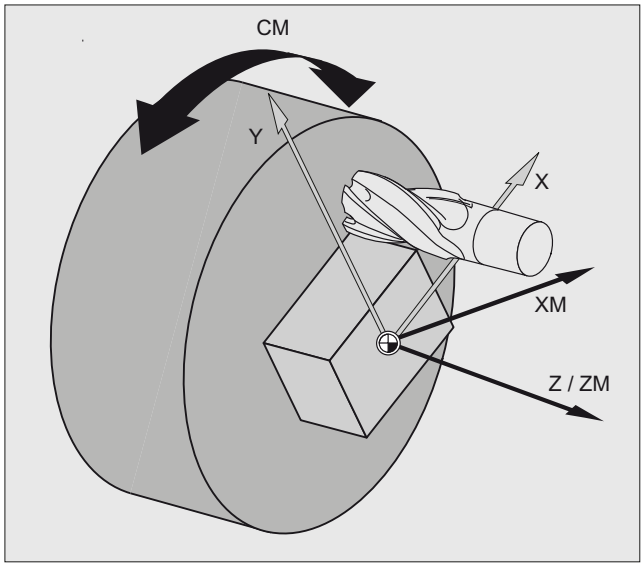
The orientation characteristic is only smoothed in blocks whose traversing distance is shorter than the configured maximum block path length (MD20178 $MC_ORISON_BLOCK_PATH_LIMIT). Blocks with longer traversing distances interrupt smoothing and are traversed as programmed.

6.8 Kinematic transformation

6.8.1 Milling on turned parts (TRANSMIT):

Function

The TRANSMIT command activates the transformation to the face side machining at lathes.



X	Geometry axis
Y	Geometry axis
Z	Geometry axis
XM	Machine axis
ZM	Machine axis
CM	Machine axis

References

For detailed information about the TRANSMIT function, please refer to:

Function Manual, Extended Functions; Chapter "Kinematic Transformation" > "Face side transformation TRANSMIT"

Syntax

```
TRANSMIT

TRANSMIT(n)

TRAFOOF
```

Meaning

`TRANSMIT`:	Activate TRANSMIT with the first TRANSMIT data set
`TRANSMIT(n)`:	Activate TRANSMIT with the nth TRANSMIT data set
`TRAFOOF`:	Deactivate transformation

Note

An active `TRANSMIT` transformation is deactivated if another transformation is active in the channel, e.g. `TRACYL`, `TRAANG`, `TRAORI`.

Example

```
Program code                                Comment
N10 T1 D1 G54 G17 G90 F5000 G94             ; Tool selection
N20 G0 X20 Z10 SPOS=45                      ; Approach the start position
N30 TRANSMIT                                ; Activate TRANSMIT with the first TRANSMIT-
                                            ; data set
N40 ROT RPL=-45                             ; Set frame
N50 ATRANS X-2 Y10
N60 G1 X10 Y-10 G41 OFFN=1                  ; Square roughing; 1 mm tolerance (OFFN)
N70 X-10
N80 Y10
N90 X10
N100 Y-10
N110 G0 Z20 G40 OFFN=0                      ; Tool change
N120 T2 D1 X15 Y-15
N130 Z10 G41
N140 G1 X10 Y-10                            ; Square part finishing
N150 X-10
N160 Y10
N170 X10
N180 Y-10
N190 Z20 G40                                ; Deselect frame
N200 TRANS
N210 TRAFOOF                                ; Deactivate TRANSMIT
N220 G0 X20 Z10 SPOS=45                     ; Approach the start position
N230 M30
```

Description

References

For a detailed description of the function, refer to:

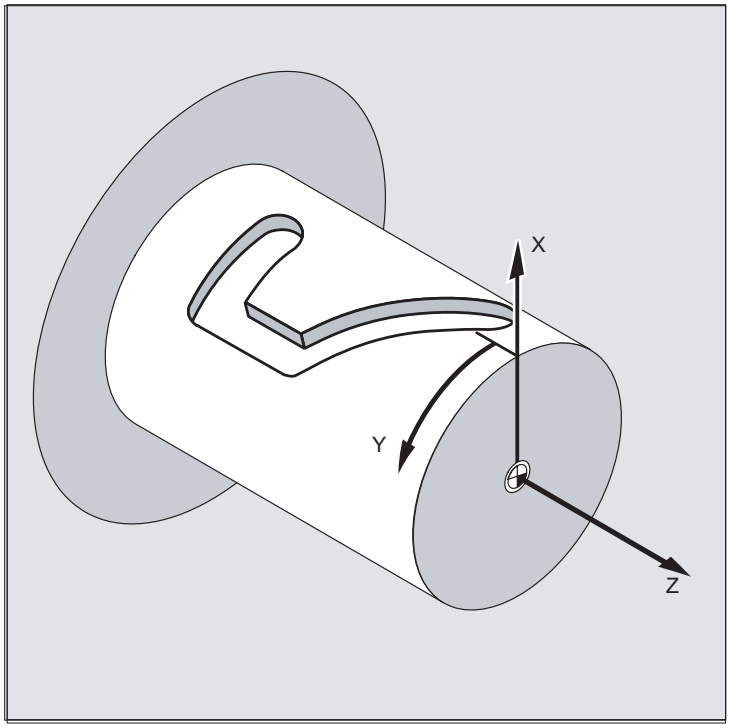
Function Manual, Extended Functions; Chapter "M1 Kinematic Transformation" > "TRANSMIT"

6.8.2 Cylinder surface transformation (TRACYL)

Function

The TRACYL command activates the transformation to machine grooves on cylindrical bodies.

The path of the grooves is programmed with reference to the unwrapped, level surface of the cylinder.



TRACYL transformation types

There are three forms of cylinder surface transformation:

- `TRACYL` without groove wall offset (transformation type 512)
- `TRACYL` with groove wall offset (transformation type 513)
- `TRACYL` with programmable groove wall offset (transformation type 514)

For cylinder surface transformation with groove side compensation, the axis used for compensation should be positioned at zero (y=0), so that the groove centric to the programmed groove center line is finished.

Axis utilization

The following axes cannot be used as a positioning axis or a reciprocating axis:

- The geometry axis in the peripheral direction of the cylinder peripheral surface (Y axis)
- The additional linear axis for groove side compensation (Z axis).

Syntax

```
TRACYL(d)
TRACYL(d, n)
TRACYL(d, n, k)
TRAFOOF
```

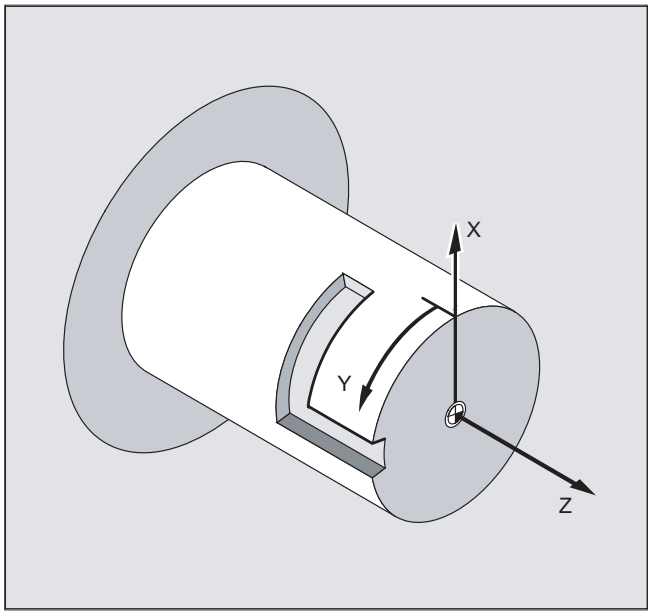
Meaning

`TRACYL(d)`	Activate TRACYL with the first TRACYL data set and working diameter d
`TRACYL (d, n)`	Activate TRACYL with the nth TRACYL data set and working diameter d
`d`	Reference or working diameter The value must be greater than 1.
`n`	TRACYL data set number (**optional**) Range of values: 1, 2
`k`	The parameter is only relevant for transformation type 514: • k = 0: without groove side correction • k = 0: with groove side correction If the parameter is not specified, then the basic position parameterized in machine data TRACYL_DEFAULT_MODE_<t> applies. (**optional**).
`TRAFOOF`	Deactivate transformation

Note

An active `TRACYL` transformation is deactivated if another transformation is active in the channel, e.g. `TRANSMIT`, `TRAANG`, `TRAORI`.

Example



Tool definition

Program code	Comment
; Tool parameters	
$TC_DP1[1,1]=120	; Tool type: Milling tool
$TC_DP2[1,1]=0	; Cutting edge position: Only for turning tools

Program code	Comment
; Geometry: Length compensation	
; Length compensation vector: Allocation to	
$TC_DP3[1,1]=8.	; Type
$TC_DP4[1,1]=9.	; Plane
$TC_DP5[1,1]=7.	

Program code	Comment
; Geometry: Radius	
$TC_DP6[1,1]=6.	; Radius
$TC_DP7[1,1]=0	; Groove width b for slotting saw, rounding radius for milling tools
$TC_DP8[1,1]=0	; Projection k: For slotting saw only
$TC_DP9[1,1]=0	
$TC_DP10[1,1]=0	
$TC_DP11[1,1]=0	; Angle for tapered milling tools

Program code	Comment
; Wear: Length and radius compensation	
$TC_DP12[1,1]=0	; Remaining parameters to $TC_DP24=0 (basis dimension/adapter)

Activate cylinder surface transformation

Program code	Comment
N10 T1 D1 G54 G90 F5000 G94	; Tool selection, clamping compensation
N20 SPOS=0	; Approach the start position
N30 G0 X25 Y0 Z105 CC=200	
N40 TRACYL(40)	; Activate TRACYL with the first TRACYL data set and
	; working diameter 40mm
N50 G19	; YZ plane

Machining a hook-shaped groove:

Program code	Comment
N60 G1 X20	; Infeed tool to groove base
N70 OFFN=12	; Define groove wall distance 12 mm relative to the
	; groove center line
N80 G1 Z100 G42	; Approach right side of groove
N90 G1 Z50	; Groove cut parallel to cylinder axis
N100 G1 Y10	; Groove cut parallel to circumference
N110 OFFN=4 G42	; Approach left groove wall
	; Define groove wall distance 4 mm relative to the
	; groove center line
N120 G1 Y70	; Groove cut parallel to circumference
N130 G1 Z100	; Groove cut parallel to cylinder axis
N140 G1 Z105 G40	; Retract from groove wall
N150 G1 X25	; Retract
N160 TRAFOOF	; Deactivate transformation
N170 G0 X25 Y0 Z105 CC=200	; Approach the start position
N180 M30	

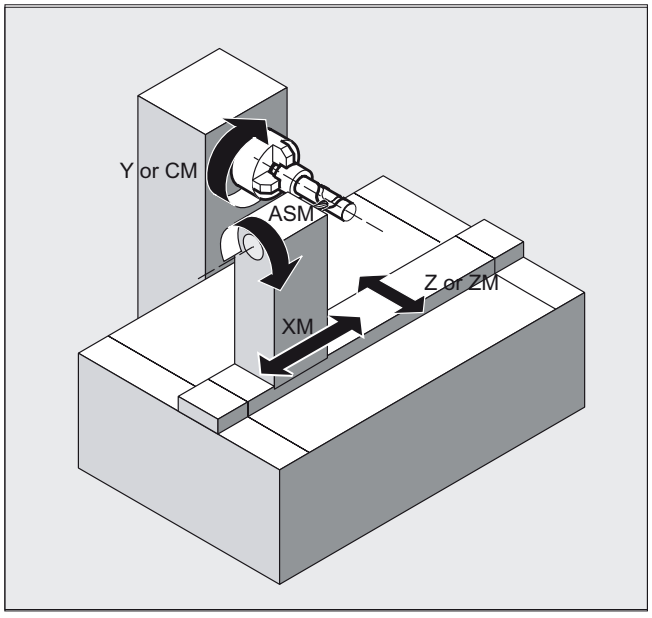
Description

Cylinder surface transformation without groove wall correction

The controller transforms the programmed traversing movements of the cylinder coordinate system to the traversing movements of the machine axes:

- Rotary axis (Y / CM)
- Infeed axis vertical to the axis of rotation (XM)
- Longitudinal axis parallel to the axis of rotation (ZM)

The linear axes are positioned perpendicular to one another.



XM	Infeed axis perpendicular to the turning center
Z / ZM	Linear axis parallel to the turning center
Y / CM	Y axis of the transformation/rotary axis
ASM	Working spindle

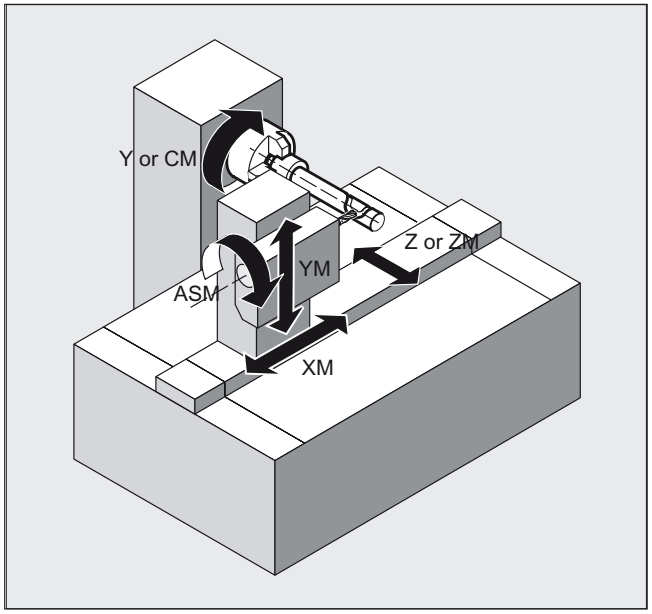
Figure 6-2 Cylinder surface transformation without groove wall correction

Cylinder surface transformation with groove wall correction

The controller transforms the programmed traversing movements of the cylinder coordinate system to the traversing movements of the machine axes:

- Rotary axis (Y / CM)
- Infeed axis vertical to the axis of rotation (XM)
- Supplementary axis for groove wall correction vertical to the X-Z plane (YM)
- Longitudinal axis parallel to the axis of rotation (ZM)

The linear axes are positioned perpendicular to one another.



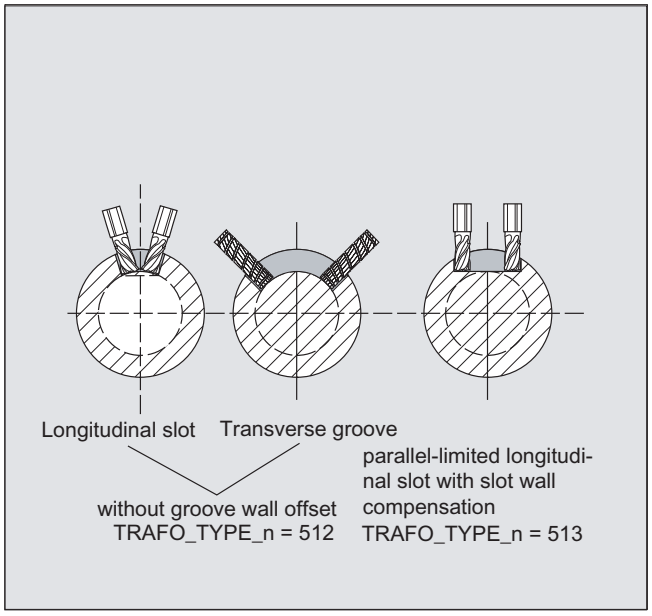
XM	Infeed axis perpendicular to the turning center
YM	Supplementary axis for groove wall correction vertical to the X-Z plane
Z / ZM	Linear axis parallel to the turning center
Y / CM	Y axis of the transformation/rotary axis
ASM	Working spindle

Figure 6-3 Cylinder surface transformation with groove wall correction

Groove edges

For a cylinder surface transformation without groove wall correction, the edges of the groove longitudinal to the rotary axis are only parallel if the groove width corresponds to the tool diameter.

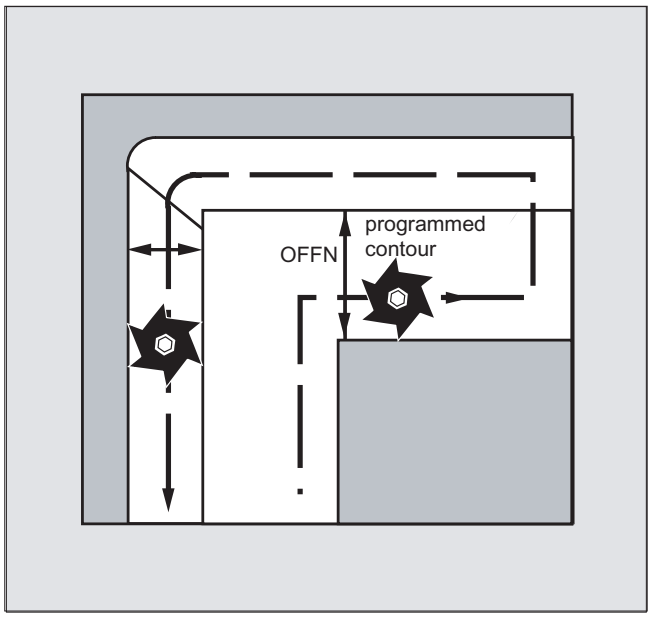
The groove edges of grooves that run parallel to the circumference (transverse grooves) are not parallel at the beginning and end.



Offset contour normal OFFN (transformation type 513)

In order to mill grooves using `TRACYL`, in the part program, the center line of the groove and using the parameter `OFFN` **half of the groove width** is programmed.

To avoid damage to the groove wall, `OFFN` acts only when the tool radius compensation is active. **Furthermore, OFFN should also be ≥ the tool radius to avoid damage occurring to the opposite side of the groove wall.**



A part program for milling a groove generally comprises the following steps:

1. Selecting a tool
2. Select TRACYL
3. Select suitable coordinate offset (frame)
4. Positioning
5. Program OFFN
6. Select TRC
7. Approach block (position TRC and approach groove side)
8. Groove center line contour
9. Deselect TRC
10. Retraction block (retract TRC and move away from groove side)
11. Positioning
12. TRAFOOF
13. Re-select original coordinate shift (frame)

Special features

- Tool radius compensation

  TRC is not taken into account relative to the groove wall, but the programmed center of the groove. In order that the tool moves to the left from the groove wall, instead of G41, G42 should be programmed. Or specify the value of OFFN with a negative sign.

- OFFN acts differently with TRACYL than it does without TRACYL. As, even without TRACYL, OFFN is included when TRC is active, OFFN should be reset to zero after TRAFOOF.
- It is possible to change OFFN within a part program. This can be used to shift the groove center line from the center (see the diagram above).
- With TRACYL and a tool, whose diameter is less than the groove width, the same groove wall geometry is not generated as with a tool whose diameter is the same as the groove width. However, TRACYL minimizes the error. To improve the precision, it is recommended that the tool diameter is selected to be only slightly less than the groove width.

Note

OFFN and TRC

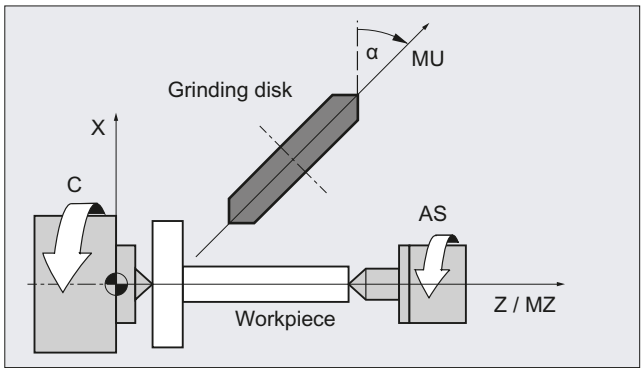
With TRAFO_TYPE_n = 512, the value of OFFN acts as an allowance for TRC.

With TRAFO_TYPE_n = 513, for OFFN, half the groove width is programmed. The contour is then machined with (OFFN - TRC).

6.8.3 Inclined axis (TRAANG)

Function

The oblique angle transformation or "inclined axis" (TRAANG) is used to simplify programming grinding machines with a linear axis that is not arranged at right angles to the turning center.



X	Geometry axis
Z	Geometry axis
MZ	Machine axis
MU	Machine axis
α	Angle of inclined axis

Syntax

```
TRAANG
TRAANG()
TRAANG(, <n>)
TRAANG(α)
TRAANG(α, <n>)
TRAFOOF
```

Meaning

Element	Description
`TRAANG` `TRAANG()`:	Activate TRAANG with the first TRAANG data set and last valid angle α
`TRAANG(, n)`:	Activate TRAANG with the nth TRAANG data set and last valid angle α
`TRAANG(α)`:	Activate TRAANG with the first TRAANG data set and angle α
`TRAANG(α, <n>)`:	Activate TRAANG with the nth TRAANG data set and angle α

Element	Description	
α:	Angle of the inclined axis (**optional**) **Note** Without specifying the angle, the value parameterized in the machine data: $MC_TRAANG_ANGLE_<n>, with n = data set number is valid	
	Range of values:	-90° < α < + 90°
<n>:	TRAANG data set number (**optional**)	
	Range of values:	1, 2
TRAFOOF:	Deactivate transformation	

Example

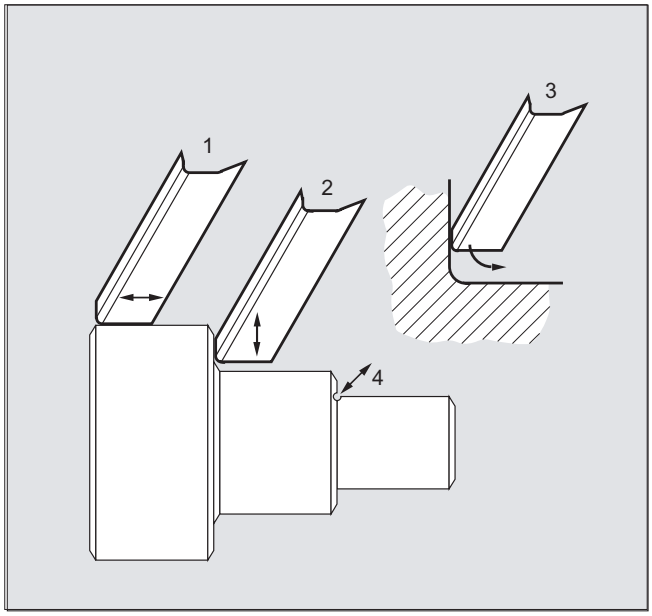
Geometry axes: Z, X

Machine axis: MU

Program code	**Comment**
N10 G0 G90 Z0 MU=10 G54 F5000 G18 G64 T1 D1	; XZ planes, tool selection, ; Clamping compensation
N20 TRAANG(45)	; Activate TRAANG with the first TRAANG data set and ; angle 45°
N30 G0 Z10 X5	; Approach the start position
N40 WAITP(Z)	; Wait for end of travel of the Z axis
N50 OSP1[Z]=10 OSP2[Z]=5 OST1[Z]=-2 OST2[Z]=-2 FA[Z]=5000	; Oscillating motion ; OSP1/OSP2: left/right reversal point ; OST1/OST2: Stopping point at the left/right reversal point
N60 OS[Z]=1	; Activate oscillation
N70 POS[X]=4.5 FA[X]=50	; Position X axis in parallel
N80 OS[Z]=0	; Deactivate oscillation
N90 WAITP(Z)	; Wait for end of travel of the Z axis
N100 TRAFOOF	; Deactivate transformation
N110 G0 Z10 MU=10	; Retract
N120 M30	

Further information

Applications



1 Longitudinal grinding
2 Face grinding
3 Contour grinding
4 Oblique plunge-cutting

References

For a detailed description of the function, refer to:

Function Manual, Extended Functions; Chapter "M1 Kinematic Transformation" > "Oblique angle transformation TRAANG"

6.8.4 Inclined axis programming (G5, G7)

Function

The G functions G7 and G5 are used to simplify the programming of oblique plunge-cutting at grinding machines with "inclined axis" (TRAANG), so that when plunge cutting, only the inclined axis is traversed.

Only the required end position of the plunge-cutting motion has to be programmed in X and Z. For G7, starting from the actual position of the X axis, the NC calculates and approaches the programmed end position and angle α of the inclined axis.

The starting position is calculated from the point where the two straight lines intersect:

- Straight line parallel to the Z axis, at a distance from the actual position of the X axis
- Straight line parallel to the inclined axis through the programmed end position

With the subsequent G5, the inclined axis is traversed to the programmed end position.

References

Function Manual, Extended Functions; Chapter "M1 Kinematic Transformation" > "Oblique angle transformation TRAANG"

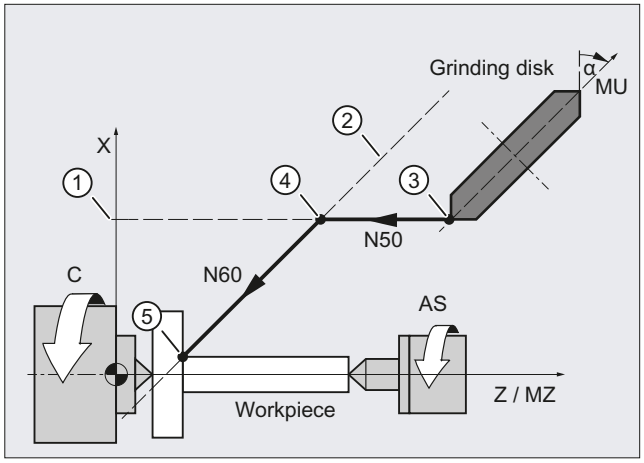
Syntax

```
G7 <Endpos_X> <Endpos_Z>

G5 <Endos_X>
```

Meaning

`G7`:	Calculate the starting position for the oblique plunge-cutting and approach
`G5`:	Traverse the inclined axis to the programmed end position
`<Endpos_X>`:	X axis end position
`<Endpos_Z>`:	End position of the Z axis

Example



① Parallel to the Z axis, at a distance from the actual position of the X axis
② Parallel to the inclined axis through the programmed end position
③ Starting position
④ Plunge-cutting: Starting position,
⑤ Plunge-cutting: End position
X Geometry axis
Z Geometry axis
MZ Machine axis
MU Machine axis

Program code	Comment
N.. G18	Select XZ plane
N40 TRAANG (45.0)	1. Activate TRAANG transformation, angle = 45°
N50 G7 X40 Z70 F4000	Calculate the starting position and approach
N60 G5 X40 F100	Traverse inclined axis to the end position
N70 ...	

6.9 Cartesian PTP travel

Function

This function can be used to program a position in a cartesian coordinate system, however, the movement of the machine occurs in the machine coordinates. The function can be used, for example, when changing the position of the articulated joint, if the movement runs through a singularity.

Note

The function can only be used meaningfully in conjunction with an active transformation. Furthermore, "PTP travel" is only permissible in conjunction with G0 and G1.

Syntax

```
N... TRAORI
N... STAT='B10' TU='B100' PTP
N... CP
```

PTP transversal with generic 5/6-axis transformation

If point-to-point travel is activated in the machine coordinate system `(ORIMKS)` during an active generic 5/6-axis transformation with PTP, tool orientation can be programmed with rotary axis positions, with Euler and/or RPY angle vectors independent of the kinematics or the direction vectors.

- Rotary axis positions: `N... G1 X Y Z A B C`
- Euler angles in ZY'X" convention (RPY angle) or ZX'Z" convention:
  `N... ORIRPY` or `N... ORIEULER`
  `N... G1 X Y Z A2 B2 C2`
- Direction vectors: `N... G1 X Y Z A3 B3 C3`

Both rotary axis interpolation, vector interpolation with large circle interpolation `ORIVECT` or interpolation of the orientation vector on a peripheral surface of a taper `ORICONxx` may be active.

Non-uniqueness of orientation with vectors

When programming the orientation with vectors, there is non-uniqueness in the rotary axis positions available. The rotary axis positions to be approached can be selected by programming `STAT = <...>`. If

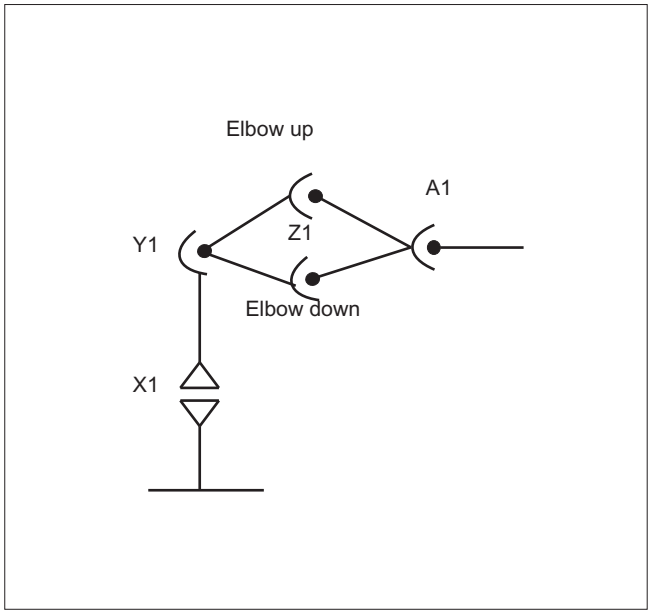
If `STAT = 0` is programmed (this is equivalent to the default setting),
the positions which are at the shortest distance from the start positions are approached. If

`STAT = 1` is programmed,
the positions which are at a greater distance from the start positions are approached.

Meaning

Command	Meaning
PTP:	**P**oint **t**o **P**oint (point to point motion) Effective: Modal
CP:	**C**ontinuous **P**ath (Cartesian path motion) Effective: Modal
STAT=:	Position of the joints. The value depends on the transformation. Effective: Modal
	A STAT value is only effective with vector interpolation.
TU=:	Axis angle Range of values: ±360 degrees Effective: Non-modal
	A TU value is effective with vector and rotary axis interpolation.

Example



Program code	Comment
N10 G0 X0 Y-30 Z60 A-30 F10000	; Initial position → elbow up
N20 TRAORI(1)	; Transformation on
N30 X1000 Y0 Z400 A0	
N40 X1000 Z500 A0 STAT='B10' TU='B100' PTP	; Re-orientation without transformation ; → elbow down
N50 X1200 Z400 CP	; Transformation active again
N60 X1000 Z500 A20	
N70 M30	

PTP transversal with generic 5-axis transformation

Assumption: This is based on a right-angled CA kinematics.

```
Program code                          Comment
TRAORI                                ; Transformation CA kinematics on
PTP                                   ; Activate PTP traversing
N10 A3=0 B3=0 C3=1                    ; Rotary axis positions C = 0 A = 0
N20 A3=1 B3=0 C3=1                    ; Rotary axis positions C = 90 A = 45
N30 A3=1 B3=0 C3=0                    ; Rotary axis positions C = 90 A = 90
N40 A3=1 B3=0 C3=1 STAT=1             ; Rotary axis positions C = 270 A = -45
```

Select clear approach position of rotary axis position:

In block N40, by programming `STAT = 1`, the rotary axes then travel the long route from their starting point (C=90, A=90) to the end point (C=270, A=–45), rather than the case would be if `STAT = 0` where they would travel the shortest route to the end point (C=90, A=45).

Description

The commands `PTP` and `CP` effect the changeover between Cartesian traversal and traversing the machine axes.

PTP transversal with generic 5/6-axis transformation

During PTP transversal, unlike 5/6–axis transformation, the TCP generally does not remain stationary if only the orientation changes. The transformed end positions of all transformation axes (3 linear axes and up to 3 round axes) are approached in linear fashion without the transformation still actually being active.

The PTP transversal is deactivated by programming the modal G code `CP`.

The various transformations are included in the document:
/FB3/ Function Manual Special Functions; Handling Transformation Package (TE4).

Programming the position (STAT=)

A machine position is not uniquely determined just by positional data with Cartesian coordinates and the orientation of the tool. Depending on the kinematics involved, there can be as many as eight different and crucial articulated joint positions. These are specific to the transformation. To be able to uniquely convert a Cartesian position into the axis angle, the position of the articulated joints must be specified with the command `STAT=`. The `"STAT"` command contains a bit for each of the possible positions as a binary value.

For information about the setting bits to be programmed for "`STAT`", see:
/FB2/ Description of Functions Extended Functions; Kinematic Transformation (M1), "Cartesian PTP travel" section.

Programming the axis angle (TU=)

To be able to clearly approach axis angles < ± 360 degrees, this information must be programmed using the command `"TU="`.

The axes traverse by the shortest path:

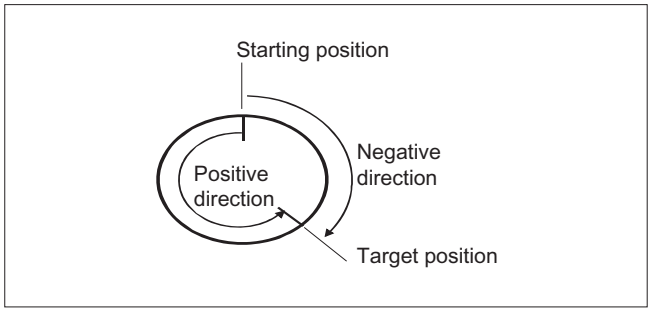
- when no TU is programmed for a position,
- with axes that have a traversing range > ±360 degrees.

Example:

The target position shown in the diagram can be approached in the negative or positive direction. The direction is programmed under address A1.

A1=225°, TU=Bit 0, → positive direction

A1=−135°, TU=Bit 1, → negative direction



Example of evaluation of TU for generic 5/6-axis transformation and target positions

Variable TU contains a bit, which indicates the traversing direction for every axis involved in the transformation. The assignment of TU bits matches the channel axis view of the round axes. The TU information is only evaluated for the up to 3 possible round axes which are included in the transformation:

Bit0: Axis 1, TU bit = 0 : 0 degrees <= round axis angle < 360 degrees

Bit1: Axis 2, TU bit = 1 : –360 degrees < round axis angle < 0 degrees

The start position of a round axis is C = 0. By programming C = 270, the round axis travels to the following target positions:

C = 270: TU bit 0, positive direction of rotation

C = –90: TU bit 1, negative direction of rotation

Further behavior

Mode change

The "Cartesian PTP travel" function is only useful in the AUTO and MDA modes of operation. When changing the mode to JOG, the current setting is retained.

When the G code PTP is set, the axes will traverse in MCS. When the G code CP is set, the axes will traverse in WCS.

Power On/RESET

After a power ON or after a RESET, the setting is dependent on the machine data $MC_GCODE_REST_VALUES[48]. The default traversal mode setting is "CP".

REPOS

If the function "Cartesian PTP travel" was set during the interruption block, PTP can also be used for repositioning.

Overlaid movements

DRF offset or external zero offset are only possible to a limited extent in Cartesian PTP travel. When changing from PTP to CP movement, there must be no overrides in the BCS.

Smoothing between CP and PTP motion

A programmable transition rounding between the blocks is possible with G641.

The size of the rounding area is the path in mm or inch, from which or to which the block transition is to be rounded. The size must be specified as follows:

- for G0 blocks with ADISPOS
- for all the other motion commands with ADIS.

The path calculation corresponds to considering of the F addresses for non-G0 blocks. The feed is kept to the axes specified in FGROUP(..).

Feed calculation

For CP blocks, the Cartesian axes of the basic coordinate system are used for the calculation.

For PTP blocks, the corresponding axes of the machine coordinate system are used for the calculation.

6.9.1 PTP for TRANSMIT

Function

PTP for TRANSMIT can be used to approach G0 and G1 blocks time-optimized. Rather than traversing the axes of the Basic Coordinate System linearly (CP), the machine axes are traversed linearly (PTP). The effect is that the machine axis motion near the pole causes the block end point to be reached much faster.

The part program is still written in the Cartesian workpiece coordinate system and all coordinate offsets, rotations and frame programming settings remain valid. The simulation on HMI, is also displayed in the Cartesian Workpiece coordinate system.

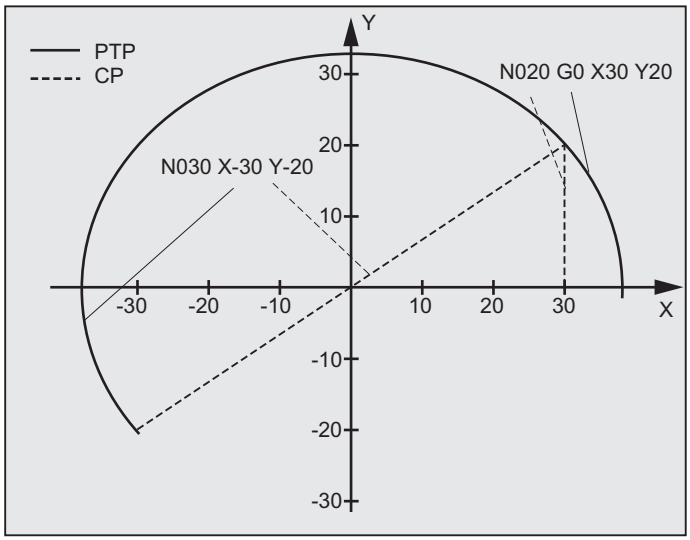
Syntax

```
N... TRANSMIT
N... PTPG0
N... G0 ...
...
N... G1 ...
```

Meaning

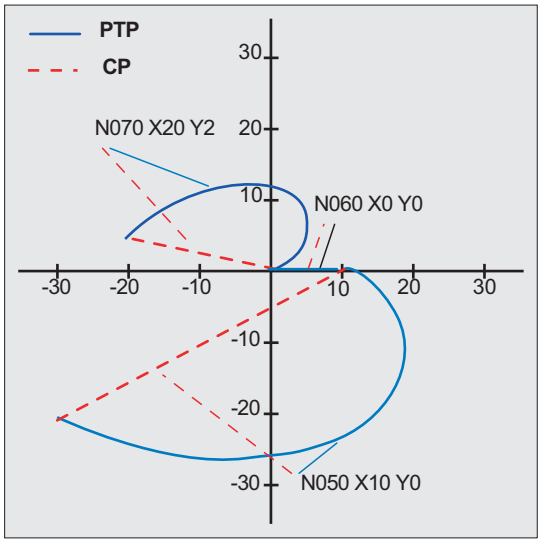
TRANSMIT	Activates the first declared TRANSMIT function (see Section "Milling on turned parts: TRANSMIT")
PTPG0	**P**oint **t**o **P**oint **G0** (point-to-point motion automatic at each G0 block and then set CP again) Because STAT and TU are modal, the most recently programmed value always acts.
PTP	**p**oint **t**o **p**oint; (point to point motion) For TRANSMIT, PTP means that in the Cartesian spirals will be retracted to Archimedean spirals either about the pole or from the pole. The resulting tool motions run significantly different as for CP and are represented in the associated programming examples.
STAT=	Resolving the non-uniqueness with regard to the pole.
TU=	TU is not relevant for PTP with TRANSMIT

Example of circumnavigation of the pole with PTP and TRANSMIT



Program code	Comment
N001 G0 X30 Z0 F10000 T1 D1 G90	; Initial setting, absolute dimension
N002 SPOS=0	
N003 TRANSMIT	; TRANSMIT transformation
N010 PTPG0	; For each G0 block, automatically PTP followed by CP
N020 G0 X30 Y20	
N030 X-30 Y-20	
N120 G1 X30 Y20	
N110 X30 Y0	
M30	

Example of the retraction from the pole with PTP and TRANSMIT



Programming	Comment
N001 G0 X90 Z0 F10000 T1 D1 G90	; Initial setting
N002 SPOS=0	
N003 TRANSMIT	; TRANSMIT transformation
N010 PTPG0	; For each G0 block, automatically PTP followed by CP
N020 G0 X90 Y60	
N030 X-90 Y-60	
N040 X-30 Y-20	
N050 X10 Y0	
N060 X0 Y0	
N070 X-20 Y2	
N170 G1 X0 Y0	
N160 X10 Y0	
N150 X-30 Y-20	
M30	

Description

PTP and PTPG0

`PTPG0` is considered for all transformations that can process `PTP`. `PTPG0` is not relevant is all other cases.

G0 blocks are processed in CP mode.

The selection of PTP or PTPG0 is performed in the parts program or by the deselection of CP in the machine data $MC_GCODE_RESET_VALUES[48].

⚠CAUTION

Restrictions

With regard to tool motions and collision, a number of restrictions and certain function exclusions apply, such as:

no tool radius compensation (TRC) may be active with PTP.

With PTPG0, for active tool radius compensation (TRC), is traversed by CP.

PTP does not permit smooth approach and retraction (SAR).

With PTPG0, CP traversal is used for smooth approach and retraction (SAR).

PTP does not permit cutting cycles (CONTPRON, CONTDCON).

With PTPG0 cutting cycles (CONTPRON, CONTDCON) are traversed by CP.

Chamfer (CHF, CHR) and rounding (RND, RNDM) are ignored.

Compressor is not compatible with PTP and will automatically be deselected in PTP blocks.

An axis superimposing in the interpolation may not change during the PTP section.

If G643 is specified, an automatic switch to G642 is made after smoothing with axial accuracy.

For active PTP, the transformation axes cannot be simultaneously positioning axes.

References:

/FB2/ Function Manual Extended Functions; Kinematic Transformation (M1), "Cartesian PTP travel" section

PTP for TRACON:

PTP can also be used with TRACON, provided the first chained transformation supports PTP.

Meaning of STAT= and TU= for TRANSMIT

If a rotary axis is to turn by 180 degrees or the contour for CP passes through the pole, rotary axes depending on the machine data $MC_TRANSMIT_POLE_SIDE_FIX_1/2 [48] can be turned by -/+ 180 degrees and traversed in clockwise or counter-clockwise direction. It can also be set whether traversal is to go through the pole or whether rotation around the pole is to be performed.

6.10 Constraints when selecting a transformation

Function

Transformations can be selected via a parts program or MDA. Please note:

- No intermediate movement block is inserted (chamfer/radii).
- Spline block sequences must be excluded; if not, a message is displayed.
- Fine tool compensation must be deselected (FTOCOF); if not a message is displayed.
- Tool radius compensation must be deselected (G40); if not a message is displayed.
- An activated tool length offset is included in the transformation by the control.
- The control deselects the current frame active before the transformation.
- The control deselects an active operating range limit for axes affected by the transformation (corresponds to WALIMOF).
- Protection zone monitoring is deselected.
- Continuous path control and rounding are interrupted.
- All the axes specified in the machine data must be synchronized relative to a block.
- Axes that are exchanged are exchanged back; if not, a message is displayed.
- A message is output for dependent axes.

Tool change

Tools may only be changed when the tool radius compensation function is deselected.

A change in tool length offset and tool radius compensation selection/deselection must not be programmed in the same block.

Frame change

All statements, which refer exclusively to the base coordinate system, are permissible (FRAME, tool radius compensation). However, a frame change with G91 (incremental dimension) – unlike with an inactive transformation – is not handled separately. The increment to be traveled is evaluated in the workpiece coordinate system of the new frame – regardless of which frame was effective in the previous block.

Exceptions

Axes affected by the transformation cannot be used

- as a preset axis (alarm),
- for approaching a checkpoint (alarm),
- for referencing (alarm).

6.11 Deselecting a transformation (TRAFOOF)

Function

The TRAFOOF command deactivates all active transformations and frames.

Note

Frames required after this must be activated by renewed programming.

Please note:

The same restrictions as for selection are applicable to deselecting the transformation (see section "Constraints when selecting a transformation").

Syntax

```
TRAFOOF
```

Meaning

TRAFOOF	Command for deactivating all active transformations/frames

6.12 Chained transformations (TRACON, TRAFOOF)

Function

Two transformations can be chained so that the motion components for the axes from the first transformation are used as input data for the chained second transformation. The motion parts from the second transformation act on the machine axes.

The chain may include **two** transformations.

Note

A tool is always assigned to the first transformation in a chain. The subsequent transformation then behaves as if the active tool length were zero. Only the basic tool lengths set in the machine data (_BASE_TOOL_) are valid for the first transformation in the chain.

Machine manufacturer

Take note of information provided by the machine manufacturer on any transformations predefined by the machine data.

Transformations and chained transformations are options. The current catalog always provides information about the availability of specific transformations in the chain in specific controls.

Applications

- Grinding contours that are programmed as a side line of a cylinder (TRACYL) using an inclined grinding wheel, e.g., tool grinding.
- Finish cutting of a contour that is not round and was generated with TRANSMIT using inclined grinding wheel.

Syntax

`TRACON(trf,par)`	This activates a chained transformation.
`TRAFOOF`	

Meaning

`TRACON`	This activates the chained transformation. If another transformation was previously activated, it is implicitly disabled by means of TRACON().
`TRAFOOF`	The most recently activated (chained) transformation will be disabled.
`trf`	Number of the chained transformation: 0 or 1 for first/single chained transformation. If nothing is programmed here, then this has the same meaning as specifying value 0 or 1, i.e., the first/single transformation is activated. 2 for the second chained transformation. (Values not equal to 0 - 2 generate an error alarm).
`par`	One or more parameters separated by a comma for the transformations in the chain expecting parameters, for example, the angle of the inclined axis. If parameters are not set, the defaults or the parameters last used take effect. Commas must be used to ensure that the specified parameters are evaluated in the sequence in which they are expected, if default settings are to be effective for previous parameters. In particular, a comma is required before at least one parameter, even though it is not necessary to specify trf. For example: TRACON(, 3.7).

Requirements

The **second** transformation must be **"Inclined axis"** (TRAANG). The first transformation can be:

- Orientation transformations (TRAORI), including universal milling head
- TRANSMIT
- TRACYL
- TRAANG

It is a condition of using the activate command for a chained transformation that the individual transformations to be chained and the chained transformation to be activated are defined by the machine data.

The supplementary conditions and special cases indicated in the individual transformation descriptions are also applicable for use in chained transformations.

Information on configuring the machine data of the transformations can be found in:

/FB2/ Function Manual Extended Functions; Kinematic Transformations (M1) and

/FB3/ Function Manual, Special Functions; 3- to 5-Axis Transformations (F2).

Kinematic chains 7

7.1 Deletion of components (DELOBJ)

Function

The following components can be deleted with the DELOBJ function:

- Elements from kinematic chains
- Protection areas and protection area elements of the geometric machine modeling
- Collision pairs
- Transformation data

To do this, all component system variables are set to their default values.

A component is not deleted immediately, but only after recalculation of the model in which the component is used.

Example:

Model: Collision model of the collision avoidance function

Deleted component: Element

The deletion only takes effect after a renewed request for the calculation of the collision model by PROTA.

Syntax

```
[<RetVal>=] DELOBJ(<CompType>[,,,<NoAlarm>)])
[<RetVal>=] DELOBJ(<CompType>,<Index1>[,,<NoAlarm>])
[<RetVal>=] DELOBJ(<CompType>[,<Index1>][,<Index2>][,<NoAlarm>])
```

Meaning

DELOBJ:	Deletion of elements from kinematic chains, protection areas and protection area elements of the geometric machine modeling, collision pairs and transformation data		
<RetVal>:	Function return value		
	Data type:	INT	
	Range of values:	0, -1, -2, ... -7	
	Value:	0	No error occurred.
		-1	Call of the function without parameters. At least parameter <CompType> must be specified.
		-2	<CompType> identifies an unknown component
		-3	<Index1> is less than -1
		-4	<Index1> is greater than the configured number of components
		-5	<Index1> has a value not equal to -1 when deleting a component group
		-6	<Index2> is less than <Index1>
		-7	<Index2> is greater than the configured number of components
<CompType>:	Component type to be deleted		
	Data type:	STRING	
	Value:	"KIN_CHAIN_ELEM"	Deletes all system variables: • $NK_...
		"PROT_AREA"	Deletes the system variables: • $NP_PROT_NAME • $NP_CHAIN_NAME • $NP_CHAIN_ELEM • $NP_1ST_PROT
		"PROT_AREA_ELEM"	Deletes the system variables: • $NP_NAME • $NP_NEXT • $NP_ADD • $NP_TYPE • $NP_PARA • $NP_OFF • $NP_DIR • $NP_ANG
		"PROT_AREA_COLL_PAIRS"	Deletes the system variables: • $NP_COLL_PAIR • $NP_SAFETY_DIST
		"PROT_AREA_ALL"	Deletes all system variables: • $NP_...

		"TRAFO_DATA"	Deletes all system variables: • $NT_...
		"TRAFO_OBJS"	Deletes all kinematic transformations not currently active. The parameters <Index1> and <Index2> are not evaluated.
<Index1>:	Start index of the components to be deleted (**optional**)		
	Data type:	INT	
	Range of values:	-1 ≤ x ≤ (maximum number of configured components -1)	
	Value:	-1	All components of the specified type are deleted. <Index2> is not evaluated.
		> -1	Index of the (first) component to be deleted
	Default value:	-1	
<Index2>:	End index of the components to be deleted (**optional**) If <Index2> is not programmed, only the system variables of the component referenced in <Index1> are deleted.		
	Data type:	INT	
	Range of values:	<Index1> < x ≤ (max. number of configured components -1)	
	Default value:	Only the system variables of the component referenced in <Index1> are deleted.	
<NoAlarm>:	Alarm suppression (**optional**)		
	Data type:	BOOL	
	Value:	FALSE	In the event of an error (<RetVal> < 0), the program processing is stopped and an alarm displayed.
		TRUE	In the event of an error, the program processing is not stopped and no alarm displayed. Application: User-specific reaction corresponding to the return value
	Default value:	FALSE	

References

Function Manual, Special Functions; Section K7: Kinematic chains

7.2 Index determination by means of names (NAMETOINT)

Function

User-specific character strings or names are entered in the system variable arrays of the STRING type. If the identifier of the system variable and the name are known, the NAMETOINT function determines the associated system variable index based on the name.

Syntax

```
<RetVal>=NAMETOINT(<SysVar>,<Name>[,<NoAlarm>])
```

Meaning

NAMETOINT:	Determination of the system variable index		
<RetVal>:	Function return value		
	Data type:	INT	
	Range of values:	-1 ≤ x ≤ (max. number of configured components -1)	
	Value:	-1	The sought name has not been found or an error has occurred.
		≥ 0	System variable index
<SysVar>:	Name of the system variable array of the STRING type		
	Data type:	STRING	
	Range of values:	Name of all NC system variable arrays of the STRING type	
<Name>:	Character string or name for which the system variable index is to be determined.		
	Data type:	STRING	
<NoAlarm>:	Alarm suppression (optional)		
	Data type:	BOOL	
	Value:	FALSE	In the event of an error (<RetVal> < 0), the program processing is stopped and an alarm displayed.
		TRUE	In the event of an error, the program processing is not stopped and no alarm displayed. Application: User-specific reaction corresponding to the return value

Example

Program code	**Comment**
`DEF INT INDEX`	
`$NP_PROT_NAME[27]="Cover"`	
`...`	
`INDEX=NAMETOINT("$NP_PROT_NAME","Cover"  ;INDEX==27`	
`)`	

References

Function Manual, Special Functions; Section K7: Kinematic chains

Collision avoidance with kinematic chains 8

Note

Protection areas

The protection areas specified in the following chapters refer to the "Geometric machine modeling" function

References:
Function Manual, Special Functions, Chapter "Geometric machine modeling"

8.1 Check for collision pair (COLLPAIR)

Function

In collision avoidance with kinematic chains, the COLLPAIR function can be used to determine whether two protection zones form a collision pair, i.e. whether they have to be monitored for collision when both are active.

Syntax

```
[<RetVal>=]COLLPAIR(<Name_1>,<Name_2>[,<NoAlarm>)])
```

Meaning

COLLPAIR:	Check whether part of a collision pair		
<RetVal>:	Function return value		
	Data type:	INT	
	Value:	≥ 0	The two protection zones form a collision pair. Return value == collision pair index m
		-1	Either two strings have not been specified or at least one of the two is the zero string.
		-2	The protection zone specified in the first parameter has not been found.
		-3	The protection zone specified in the second parameter has not been found.
		-4	Neither of the two specified protection zones has been found.
		-5	Both specified protection zones have been found, but not together in a collision pair.

<Name_1>:	Name of the first protection zone		
	Data type:	STRING	
	Range of values:	Parameterized protection zone names	
<Name_2>:	Name of the second protection zone		
	Data type:	STRING	
	Range of values:	Parameterized protection zone names	
<NoAlarm>:	Alarm suppression (optional)		
	Data type:	BOOL	
	Value:	FALSE	In the event of an error (<RetVal> < 0), the program processing is stopped and an alarm displayed.
		TRUE	In the event of an error, the program processing is not stopped and no alarm displayed. Application: User-specific reaction corresponding to the return value
	Default value:	FALSE	

References

Function Manual, Special Functions; Section K9: Collision avoidance

8.2 Requesting a recalculation of the collision model (PROTA)

Function

The collision model can be changed by the writing of system parameters for kinematic chains, geometric machine modeling and/or collision avoidance in the part program or via the OPI. For the changes to take effect, a recalculation of the model must be requested with the PROTA procedure.

Protection zone status

With the call of the PROTA procedure, a recalculation of the collision model is performed **without** changing the protection zone status. A **newly** defined protection zone is then in the initialization status. A protection zone whose name has been changed is **not** considered to be newly defined. Its status remains unchanged.

With the call of the PROTA procedure with parameter "R", a recalculation of the collision model is performed **with** change of the protection zone status. All protection zones are reset to their respective initialization status corresponding to $NP_INIT_STAT.

Note

Tool change and automatically created tool protection zones

After a tool change, the collision model is implicitly recalculated for automatically created tool protection zones.

Syntax

```
PROTA
PROTA(<Par>)
```

Meaning

PROTA:	Request for a recalculation of the collision model	
	Preprocessing stop:	Yes
<Par>:	Parameter	
	Data type:	STRING
	Range of values:	"R" With the recalculation of the collision model, all protection zones are reset to their respective initialization status.

Supplementary conditions

Simulation

The PROTA procedure must not be used in part programs in conjunction with the simulation (simNCK).

Example:

```
Program code                    Comment
...
IF $P_SIM == FALSE              ;IF simulation not active
 PROTA                          ;THEN recalculate collision model
ENDIF                           ;ENDIF
...
```

References

Function Manual, Special Functions; Section K9: Collision avoidance

8.3 Setting the protection zone status (PROTS)

Function

The status of protection zones can be set for collision avoidance with kinematic chains with the PROTS procedure.

Syntax

```
PROTS(<Status>)
PROTS(<Status>,<Name_1>)
PROTS(<Status>,<Name_1>,...,<Name_n>)
```

Meaning

PROTS:	Setting the protection zone status		
	Preprocessing stop:	No	
	Alone in the block:	Yes	
<State>:	Status to which the specified protection zones are to be set		
	Data type:	CHAR	
	Value:	"A"or "a"	Status: Active
		"I"or "i"	Status: Inactive
		"P"or "p"	Status: Preactivated (activation performed via NC/PLC interface)
		"R"or "r"	Status = $NP_INIT_STAT (initialization status)
<Name_1> ... <Name_n>:	Name of one or more protection zones that are to be set to the specified status **Note:** The maximum number of protection zones that can be specified as parameters depends only on the maximum possible number of characters per program line.		
	Data type:	STRING	
	Range of values:	Parameterized protection zone names **Note:** If no name is specified, the specified status is set for all defined protection zones.	

References

Function Manual, Special Functions; Section K9: Collision avoidance

8.4 Determining the clearance of two protection zones (PROTD)

Function

The clearance of two protection zones can be calculated for collision avoidance with kinematic chains with the PROTD function.

Function properties:

- The clearance calculation is performed independent of the protection zone status (activated, deactivated, preactivated).
- The clearance calculation is performed with the positions valid at the end of the previous block.
- Overlays that are included in the main run calculation (e.g. DRF offset or external work offset) are included in the clearance calculation with the values valid at the function **interpretation time**.

Note

Synchronization

If the PROTD function is used, it is the sole responsibility of the user to synchronize the main run and preprocessing, if required, with the STOPRE preprocessing stop.

Collision

If there is a collision between the two specified protection zones, the function returns a clearance of 0.0. There is a collision when the following applies for the clearance:

0.0 < clearance < MD10619 $MN_COLLISION_TOLERANCE (tolerance for collision check)

The safety clearance for the collision check (MD10622 $MN_COLLISION_SAFETY_DIST) is not taken into account in the clearance calculation.

Syntax

```
[<RetVal>=] PROTD(<Name_1>,<Name_2>,VAR <Vector>[,<System>])
[<RetVal>=] PROTD(,,VAR <Vector>[,<System>])
```

Meaning

PROTD:	Calculates the clearance of the two specified protection zones.		
	Preprocessing stop:	No	
	Alone in the block:	Yes	
<RetVal>:	Function return value: Absolute clearance value of the two protection zones or 0.0 with collision (see above, collision paragraph)		
	Data type:	REAL	
	Range of values:	0.0 ≤ x ≤ +max. REAL value	
<Name_1>, <Name_2>:	Names of the two protection zones whose clearance is to be calculated (**optional**).		
	Data type:	STRING	
	Range of values:	Parameterized protection zone names	
	Default value:	If no protection zones have been specified, the function calculates the current smallest clearance from all the activated and preactivated protection zones in the collision model.	
<Vector>:	Return value: 3-dimensional clearance vector from protection zone <Name_2> to protection zone <Name_1> with: • <Vector>[0]: X coordinate in the world coordinate system • <Vector>[1]: Y coordinate in the world coordinate system • <Vector>[2]: Z coordinate in the world coordinate system With collision: <Vector> == zero vector		
	Data type:	VAR REAL[3]	
	Range of values:	<Vector>[n]: 0.0 ≤ x ≤ ±max. REAL value	
<System>:	Measuring system (inch/metric) for clearance and clearance vector (**optional**)		
	Data type:	BOOL	
	Value:	FALSE	Measuring system corresponding to the currently active G function from G group 13 (G70, G71, G700, G710)).
		TRUE	Measuring system corresponding to the set basic system: MD52806 $MN_ISO_SCALING_SYSTEM
	Default value:	FALSE	

References

Function Manual, Special Functions; Section K9: Collision avoidance

Tool offsets

9

9.1 Offset memory

Function

Structure of the offset memory

Every data field can be invoked with a T and D number (except "Flat D No."); in addition to the geometrical data for the tool, it contains other information such as the tool type.

Flat D number structure

The "Flat D No. structure" is used if tool management takes place outside the NCK. In this case, the D numbers are created with the corresponding tool compensation blocks without assignment to tools.

T can continue to be programmed in the part program. However, this T has no reference to the programmed D number.

User cutting edge data

User cutting edge data can be configured via machine data. Please refer to the machine manufacturer's instructions.

Tool parameters

Note

Individual values in the offset memory

The individual values of the offset memory P1 to P25 can be read and written by the program via system variables. All other parameters are reserved.

The tool parameters $TC_DP6 to $TC_DP8, $TC_DP10 and $TC_DP11 as well as $TC_DP15 to $TC_DP17, $TC_DP19 and $TC_DP20 have another meaning depending on tool type.

Tool parameter number (DP)	Meaning of system variables	Remark
$TC_DP1	Tool type	For overview see list
$TC_DP2	Cutting edge position	Only for turning tools
Geometry	**Length compensation**	
$TC_DP3	Length 1	Allocation to
$TC_DP4	Length 2	Type and level

Tool parameter number (DP)	Meaning of system variables	Remark
$TC_DP5	Length 3	
Geometry	**Radius**	
$TC_DP6 [1] $TC_DP6 [2]	Radius 1 / length 1 diameter d	Milling/turning/grinding tool Slotting saw
$TC_DP7 [1] $TC_DP7 [2]	Length 2 / corner radius, tapered milling tool Slot width b corner radius	Milling tools Slotting saw
$TC_DP8 [1] $TC_DP8 [2]	Rounding radius 1 for milling tools projecting length k	Milling tools Slotting saw
$TC_DP9 [1] [3]	Rounding radius 2	Reserved
$TC_DP10 [1]	Angle 1 face end of tool	Tapered milling tools
$TC_DP11 [1]	Angle 2 tool longitudinal axis	Tapered milling tools
Wear	**Length and radius compensation**	
$TC_DP12	Length 1	
$TC_DP13	Length 2	
$TC_DP14	Length 3	
$TC_DP15 [1] $TC_DP15 [2]	Radius 1 / length 1 diameter d	Milling/turning/grinding tool Slotting saw
$TC_DP16 [1] $TC_DP16 [3]	Length 2 / corner radius, tapered milling tool, slot width b corner radius	Milling tools Slotting saw
$TC_DP17 [1] $TC_DP17 [2]	Rounding radius 1 for milling tools projecting length k	Milling / 3D face milling Slotting saw
$TC_DP18 [1] [3]	Rounding radius 2	Reserved
$TC_DP19[1]	Angle 1 face end of tool	Tapered milling tools
$TC_DP20[1]	Angle 2 tool longitudinal axis	Tapered milling tools
Tool base dimension/ adapter	**Length offsets**	
$TC_DP21	Length 1	
$TC_DP22	Length 2	
$TC_DP23	Length 3	
Technology		
$TC_DP24	Clearance angle	Only for turning tools
$TC_DP25		Reserved

[1] Also applies with milling tools for 3D face milling

[2] For slotting saw tool type

[3] Reserved (is not used by SINUMERIK 840D sl)

Remarks

Several entry components are available for geometric variables (e.g. length 1 or radius). These are added together to produce a value (e.g. total length 1, total radius), which is then used for the calculations.

Offset values not required must be assigned the value zero.

Tool parameters $TC-DP1 to $TC-DP23 with contour tools

Note

The tool parameters not listed in the table, such as $TC_DP7, are not evaluated, i.e. their content is meaningless.

Tool parameter number (DP)	Meaning	Cutting Dn		Remark
$TC_DP1	Tool type			400 to 599
$TC_DP2	Cutting edge position			
Geometry	**Length compensation**			
$TC_DP3	Length 1			
$TC_DP4	Length 2			
$TC_DP5	Length 3			
Geometry	**Radius**			
$TC_DP6	Radius			
Geometry	**Limit angle**			
$TC_DP10	Minimum limit angle			
$TC_DP11	Maximum limit angle			
Wear	**Length and radius compensation**			
$TC_DP12	Wear length 1			
$TC_DP13	Wear length 2			
$TC_DP14	Wear length 3			
$TC_DP15	Wear radius			
Wear	**Limit angle**			
$TC_DP19	Wear min. limit angle			
$TC_DP20	Wear max. limit angle			
Tool base dimension/ adapter	**Length offsets**			
$TC_DP21	Length 1			
$TC_DP22	Length 2			
$TC_DP23	Length 3			

Basic value and wear value

The resultant values are each a total of the basic value and wear value (e.g. $TC_DP6 + $TC_DP15 for the radius). The basic measurement ($TC_DP21 – $TC_DP23) is also added to the tool length of the first cutting edge. All the other parameters, which may also impact on effective tool length for a standard tool, also affect this tool length (adapter, orientational toolholder, setting data).

Limit angles 1 and 2

Limit angles 1 and 2 each relate to the vector of the cutting edge center point to the cutting edge reference point and are counted clockwise.

9.2 Additive offsets

9.2.1 Selecting additive offsets (DL)

Function

Additive offsets can be considered as process offsets that can be programmed in the machining. They refer to the geometrical data of a cutting edge and are therefore a component of tool cutting data.

Data of an additive offset are addressed using a DL number (DL: Locationdependent; offsets regarding the location of use) and entered via the operator interface.

Application

Dimension errors caused be the location of use can be compensated using additive offsets.

Syntax

```
DL=<number>
```

Meaning

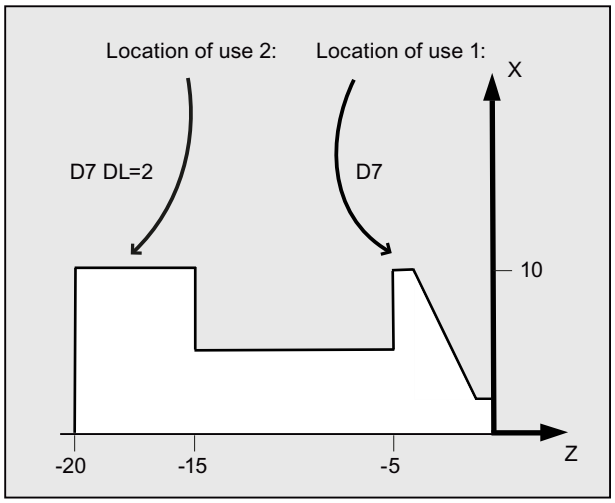
Element	Description
DL:	Command to activate an additive offset
<number>:	The additive tool offset data to be activated is specified using the <number> parameter

Note

The machine data is used to define the number of additive offsets and also activate them (→ carefully observe the machine OEM's data!).

Example

The same cutting edge is used for two bearing seats:




```
Program code                    Comment
N110 T7 D7                      ; The revolver is positioned to location 7. D7 and DL=1
                                  are activated and moved through in the next block.
N120 G0 X10 Z1
N130 G1 Z-6
N140 G0 DL=2 Z-14               ; DL=2 is activated in addition to D7 and is moved
                                  through in the next block.
N150 G1 Z-21
N160 G0 X200 Z200               ; Approach tool change position.
...
```

9.2.2 Specify wear and setup values ($TC_SCPxy[t,d], $TC_ECPxy[t,d])

Function

Wear and setting-up values can be read and written to using system variables. The logic is based on the logic of the corresponding system variables for tools and tool noses.

System variables

System variable	Significance
$TC_SCPxy[<t>,<d>]	Wear values that are assigned to the particular geometry parameters via xy, whereby x corresponds to the number of the wear value and y establishes the reference to the geometry parameter.
$TC_ECPxy[<t>,<d>]	Setting-up values that are assigned to the particular geometry parameter via xy, whereby x corresponds to the number of the setting-up value and y establishes the reference to the geometry parameter.
<t>: T number of the tool <d>: D number of the tool cutting edge	

Note

The defined wear and setup values are added to the geometry parameters and the other offset parameters (D numbers).

Example

The wear value of length 1 is set to the value of 1.0 for the cutting edge <d> of tool <t>.

Parameter: $TC_DP**3** (length 1, with turning tools)

Wear values: $TC_SCP1**3** to $TC_SCP6**3**

Setup values: $TC_ECP1**3** to $TC_ECP6**3**

$TC_SCP4**3** [<t>,<d>] = 1.0

9.2.3 Delete additive offsets (DELDL)

Function

The `DELDL` command deletes the additive offsets for the cutting edge of a tool (to release memory space). Both the defined wear values and the setup values are deleted.

Syntax

```
DELDL[<t>,<d>]
DELDL[<t>]
DELDL
<Status>=DELDL[<t>,<d>]
```

Meaning

`DELDL`	Command to delete additive offsets
`<t>`	T number of the tool
`<d>`	D number of the tool cutting edge
`DELDL[<t>,<d>]`	All additive offsets of the cutting edges `<d>` of the tool `<t>` are deleted.
`DELDL[<t>]`	All additive offsets of all cutting edges of tool `<t>` are deleted.
`DELDL`	All additive offsets of all cutting edges of all tools of the TO unit are deleted (for the channel in which the command is programmed).
`<status>`	Delete status Value: Meaning: 0 Deletion was successfully completed. - Offsets have not been deleted (if the parameter settings specify exactly one tool edge), or not deleted completely (if the parameter settings specify several cutting edges).

Note

Wear and setting-up values of active tools cannot be deleted (essentially the same as the delete behavior of `D` or tool data).

9.3 Special handling of tool offsets

Function

The evaluation of the sign for tool length and wear can be controlled using setting data SD42900 to SD42960.

The same applies to the behavior of the wear components when mirroring geometry axes or changing the machining plane, and also to temperature compensation in tool direction.

Wear values:

If reference is made to wear values in the following, then this should be understood as the sum of the actual wear values ($TC_DP12 to $TC_DP20) and the sum offsets with the wear values ($SCPX3 to $SCPX11) and setting-up values ($ECPX3 to $ECPX11).

More information on summed offsets, refer to:
References:
Function Manual, Tool Management

Setting data

Setting Data	Significance
SD42900 $SC_MIRROR_TOOL_LENGTH	Mirroring of tool-length components and components of the tool base dimension.
SD42910 $SC_MIRROR_TOOL_WEAR	Mirroring of wear values of the tool-length components.
SD42920 $SC_WEAR_SIGN_CUTPOS	Evaluating the sign of the wear components as a function of the tool nose position.
SD42930 $SC_WEAR_SIGN	Inverts the sign of wear dimensions.
SD42935 $SC_WEAR_TRANSFORM	Transformation of wear values.
SD42940 $SC_TOOL_LENGTH_CONST	Assignment of tool length components to geometry axes.
SD42950 $SC_TOOL_LENGTH_TYPE	Assignment of the tool length components independent of tool type.
SD42960 $SC_TOOL_TEMP_COMP	Temperature compensation value in tool direction. Also operative when tool orientation is programmed.

References

Function Manual Basic Functions; Tool Offset (W1)

Further Information

Activation of modified setting data

When the setting data described above are modified, the tool components are not reevaluated until the next time a tool edge is selected. If a tool is already active and the data of this tool are to be reevaluated, the tool must be selected again.

The same applies in the event that the resulting tool length is modified due to a change in the mirroring status of an axis. The tool must be selected again after the mirror command, in order to activate the modified tool-length components.

Orientable toolholders and new setting data

Setting data SD42900 to SD42940 have no effect on the components of an active toolholder with orientation capability. However, the calculation with an orientable toolholder always allows for a tool with its total resulting length (tool length + wear + tool base dimension). All modifications initiated by the setting data are included in the calculation of the resulting total length; i.e., vectors of the orientable toolholder are independent of the machining plane.

Note

When orientable toolholders are used, it is frequently practical to define all tools for a non-mirrored basic system, even those which are only used for mirrored machining. When machining with mirrored axes, the toolholder is then rotated such that the actual position of the tool is described correctly. All tool-length components then automatically act in the correct direction, dispensing with the need for control of individual component evaluation via setting data, depending on the mirroring status of individual axes.

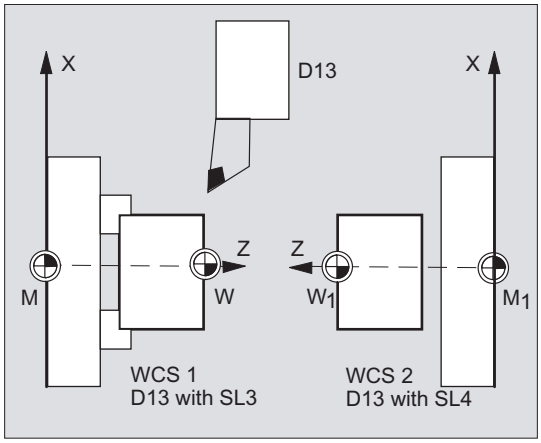
Further application options

The use of orientable toolholder functionality can also be useful if there is no physical option of turning tools on the machine, even though tools with different orientations are permanently installed. Tool dimensioning can then be performed uniformly in a basic orientation, where the dimensions relevant for machining are calculated according to the rotations of a virtual toolholder.

9.3.1 Mirroring of tool lengths

Function

When setting data SD42900 $SC_MIRROR_TOOL_LENGTH and SD42910 $SC_MIRROR_TOOL_WEAR are not set to zero, then you can mirror the tool length components and components of the basis dimensions with wear values and their associated axes.



SD42900 $SC_MIRROR_TOOL_LENGTH

Setting data **not equal to** zero:

The tool length components ($TC_DP3, $TC_DP4 and $TC_DP5) and the components of the basis dimensions ($TC_DP21, $TC_DP22 and $TC_DP23) are mirrored against their associated axes, also mirrored – by inverting the sign.

The wear values are **not** mirrored. If these are also be be mirrored, then setting data SD42910 $SC_MIRROR_TOOL_WEAR must be set.

SD42910 $SC_MIRROR_TOOL_WEAR

Setting data **not equal to** zero:

The wear values of the tool length components - whose associated axes are mirrored - are also mirrored by inverting the sign.

9.3.2 Wear sign evaluation

Function

When setting data SD42920 $SC_WEAR_SIGN_CUTPOS and SD42930 $SC_WEAR_SIGN are set not equal to zero, then you can invert the sign evaluation of the wear components.

SD42920 $SC_WEAR_SIGN_CUTPOS

Setting data **not equal to** zero:

For tools with the relevant tool nose position (turning and grinding tools, tool types 400), then the sign evaluation of the wear components in the machining plane depends on the tool nose position. This setting data is of no significance for tool types without relevant tool nose position.

In the following table, the dimensions, whose sign is inverted using SD42920 (not equal to zero), are designed using an X:

Tool nose position	Length 1	Length 2
1		
2		X
3	X	X
4	X	
5		
6		
7		X
8	X	
9		

Note

The sign evaluation using SD42920 and SD42910 are independent of one another. If e.g. the the sign of a dimension is changed using both setting data, then the resulting sign remains unchanged.

SD42930 $SC_WEAR_SIGN

Setting data **not equal to** zero:

Inverts the sign of all wear dimensions. This affects both the tool length and other variables such as tool radius, rounding radius, etc.

If a positive wear dimension is entered, the tool becomes "shorter" and "thinner", refer to Chapter "tool offset, special handling", activating changed setting data".

9.3.3 Coordinate system of the active machining operation (TOWSTD, TOWMCS, TOWWCS, TOWBCS, TOWTCS, TOWKCS)

Function

Depending on the kinematics of the machine or the availability of an orientable toolholder, the wear values measured in one of these coordinate systems are converted or transformed to a suitable coordinate system.

Coordinate systems of active machining operation

The following coordinate systems can produce tool length offsets that can be used to incorporate the tool length component "wear" into an active tool via the corresponding G code of Group 56.

- Machine coordinate system (MCS)
- Basic coordinate system (BCS)
- Workpiece coordinate system (WCS)
- Tool coordinate system (TCS)
- Tool coordinate system of kinematic transformation (KCS)

Syntax

```
TOWSTD
TOWMCS
TOWWCS
TOWBCS
TOWTCS
TOWKCS
```

Meaning

`TOWSTD`	Initial setting value for offsets in tool length wear value
`TOWMCS`	Offsets in tool length in MCS
`TOWWCS`	Offsets in tool length in WCS
`TOWBCS`	Offsets in tool length in BCS

TOWTCS	Offsets of tool length at toolholder reference point (orientable toolholder)
TOWKCS	Offsets of tool length at tool head (kinematic transformation)

Further Information

Distinguishing features

The most important distinguishing features are shown in the following table:

G code	Wear value	Active orientable toolholder
TOWSTD	Initial value, tool length	Wear values are subject to rotation.
TOWMCS	Wear value in MCS. TOWMCS is identical to TOWSTD if a tool holder that can be orientated is not active.	It only rotates the vector of the resultant tool length without taking into account the wear.
TOWWCS	The wear value is converted to the MCS in the WCS.	The tool vector is calculated as for TOWMCS without taking into account the wear.
TOWBCS	The wear value is converted to the MCS in the BCS.	The tool vector is calculated as for TOWMCS without taking into account the wear.
TOWTCS	The wear value is converted to the MCS in the workpiece coordinate system.	The tool vector is calculated as for TOWMCS without taking into account the wear.

TOWWCS, TOWBCS, TOWTCS: The wear vector is added to the tool vector.

Linear transformation

The tool length can be defined meaningfully in the MCS only if the MCS is generated by linear transformation from the BCS.

Non-linear transformation

For example, if with TRANSMIT a non-linear transformation is active, then when specifying the MCS as requested coordinate system, BCS is automatically used.

No kinematic transformation and no orientable toolholder

If neither a kinematic transformation nor an orientable toolholder is active, then all the other four coordinate systems (except for the WCS) are combined. It is then only the WCS, which is different to the other systems. Since only tool lengths need to be evaluated, translations between the coordinate systems are irrelevant.

References:

For more information on tool compensation, see:
Function Manual Basic Functions; Tool Offset (W1)

Inclusion of wear values in calculation

The setting data **SD42935 $SC_WEAR_TRANSFORM** defines which of the three wear components:

- Wear
- Total offsets fine
- Total offsets coarse

should be subject to a rotation using adapter transformation or a tool holder that can be orientated if one of the following G codes is active:

- `TOWSTD` Default setting

  For offsets in the tool length
- `TOWMCS` wear values

  In the machine coordinate system (MCS)
- `TOWWCS` wear values

  In the workpiece coordinate system (WCS)
- `TOWBCS` wear values (BCS)

  In the basic coordinate system
- `TOWTCS` wear values in the tool coordinate system at the tool holder reference (T tool holder reference)
- `TOWKCS` Wear values in the coordinate system of the tool head for kinematic transformation

Note

Evaluation of individual wear components (assignment to geometry axes, sign evaluation) is influenced by:

- The active plane
- The adapter transformation
- Following setting data:
  - SD42910 $SC_MIRROW_TOOL_WEAR
  - SD42920 $SC_WEAR_SIGN_CUTPOS
  - SD42930 $SC_WEAR_SIGN
  - SD42940 $SC_TOOL_LENGTH_CONST
  - SD42950 $SC_TOOL_LENGTH_TYPE

9.3.4 Tool length and plane change

Function

When setting data SD42940 $SC_TOOL_LENGTH_CONST is set not equal to zero, then you can assign the tool length components – such as lengths, wear and basic dimension – to the geometry axes for turning and grinding tools when changing the plane.

SD42940 $SC_TOOL_LENGTH_CONST

Setting data **not equal to** zero:

The assignment of tool length components (length, wear and tool base dimension) to geometry axes does not change when the machining plane is changed (`G17` - `G19`).

The following table shows the assignment of tool length components to geometry axes for turning and grinding tools (tool types 400 to 599):

Content	Length 1	Length 2	Length 3
17	Y	X	Z
*)	X	Z	Y
19	Z	Y	X
-17	X	Y	Z
-18	Z	X	Y
-19	Y	Z	X

*) Each value not equal to 0, which is not equal to one of the six listed values, is evaluated as value 18.

The following table shows the assignment of tool length components to geometry axes for all other tools (tool types < 400 or > 599):

Operating plane	Length 1	Length 2	Length 3
*)	Z	Y	X
18	Y	X	Z
19	X	Z	Y
-17	Z	X	Y
-18	Y	Z	X
-19	X	Y	Z

*) Each value not equal to 0, which is not equal to one of the six listed values, is evaluated as value 17.

Note

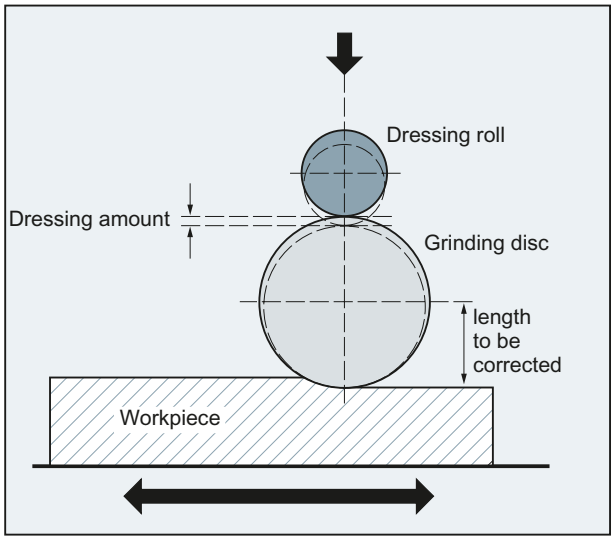
For representation in tables, it is assumed that geometry axes up to 3 are designated with X, Y, Z. The axis order and not the axis identifier determines the assignment between a compensation and an axis.

9.4 Online tool offset (PUTFTOCF, FCTDEF, PUTFTOC, FTOCON, FTOCOF)

Function

When the "Online tool offset" function is active, a tool length offset resulting from the machining is applied immediately on grinding tools.

An application example is CD dressing, where the grinding wheel is dressed in parallel to machining.



The tool length offset can be changed from the machining channel or a parallel channel (dresser channel).

The online tool offset is written using various functions dependent on the timing of the dressing process:

- Continuous write, non-modal (PUTFTOCF)

  With PUTFTOCF, dressing is carried out at the same time as machining.

  The tool offset is changed continuously in the machining channel according to a polynomial function of the first, second or third order, which must have been defined previously with FCTDEF.

  PUTFTOCF is always non-modal; in other words, it takes effect in the subsequent traversing block.

- Continuous write, modal: ID=1 DO FTOC (see "Synchronized actions (Page 553)")

- Discrete write (PUTFTOC)

  With PUTFTOC, dressing is not carried out at the same time as machining from a parallel channel. The offset value specified with PUTFTOC takes effect immediately in the destination channel.

Note

Online tool offset can be applied only to grinding tools.

Syntax

Activate/deactivate online tool offset in the destination channel:

```
FTOCON
...
FTOCOF
```

Write online tool offset:

- Continuous, non-modal:

```
FCTDEF(<function>,<LLimit>,<ULimit>,<a0>,<a1>,<a2>,<a3>)
PUTFTOCF(<function>,<reference value>,<tool parameter>,<channel>,<spindle>)
...
```

- Discrete:

```
PUTFTOC(<offset value>,<tool parameter>,<channel>,<spindle>)
...
```

Meaning

`FTOCON`: Activate online tool offset

`FTOCON` must be written in the channel in which the online tool offset is to take effect.

`FTOCOF`: Cancel online tool offset

With `FTOCOF`, the offset is no longer applied; however, the complete value written with `PUTFTOC` is corrected in the cutting-edge-specific offset data.

Note:
In order to definitively deactivate the online tool offset, the tool (`T...`) still needs to be selected/deselected after `FTOCOF`.

`FCTDEF`: `FCTDEF` is used to define the polynomial function for `PUTFTOCF`.

Parameter:

`<function>`: Number of the polynomial function
Type: INT

`<LLimit>`: Lower limit value
Type: REAL

`<ULimit>`: Upper limit value
Type: REAL

`<a0> ... <a3>`: Coefficients of polynomial function
Type: REAL

`PUTFTOCF`: Call the "Continuous non-modal write of online tool offset" function

Parameter:

`<function>`: Number of the polynomial function

Type: INT

Note:
Must match the setting for `FCTDEF`.

`<reference value>`: Variable reference value from which the offset is to be derived (e.g. changing actual value).

Type: VAR REAL

`<tool parameter>`: Number of the wear parameter (length 1, 2 or 3) in which the offset value is to be added.

Type: INT

`<channel>`: Number of the channel in which the online tool offset is to take effect.

Type: INT

Note:
A channel number only has to be specified if the offset is not to take effect in the active channel.

`<spindle>`: Number of the spindle for which the online tool offset is to take effect.

Type: INT

Note:
A spindle number only has to be specified if the offset is to be applied to a non-active grinding wheel rather than the active tool which is currently in use.

`PUTFTOC`: Call the "Discrete write of online tool offset" function.

Parameter:

`<offset value>`: Offset value to be added in the wear parameter.

Type: REAL

`<tool parameter>`: See `PUTFTOCF`

`<channel>`: Number of the channel in which the online tool offset is to take effect.

Type: INT

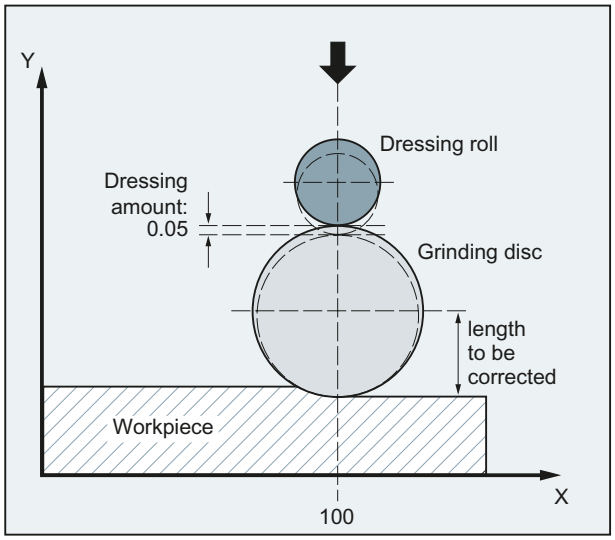
`<spindle>`: See `PUTFTOCF`

Example

Surface grinding machine with:

- Y: Infeed axis for grinding wheel
- V: Infeed axis for dressing roller
- Machining channel: Channel 1 with axes X, Z, Y
- Dressing channel: Channel 2 with axis V

After the start of grinding motion, the grinding wheel is to be dressed by an amount of 0.05 at X100. The dressing amount is to be applied to the grinding tool with "Write online offset continuously".



Machining program in channel 1:

Program code	Comment
…	
N110 G1 G18 F10 G90	; Basic position.
N120 T1 D1	; Select current tool.
N130 S100 M3 X100	; Spindle on, traverse to starting position.
N140 INIT(2,"DRESS","S")	; Select the dressing program in channel 2.
N150 START(2)	; Start the dressing program in channel 2.
N160 X200	; Traverse to the target point.
N170 FTOCON	; Activate online offset.
N… G1 X100	; Additional machining.
N… M30	

Dressing program in channel 2:

```
Program code                                    Comment
…
N40 FCTDEF(1,-1000,1000,-$AA_IW[V],1)           ; Define function: Straight line with
                                                  gradient = 1
N50 PUTFTOCF(1,$AA_IW[V],3,1)                   ; Continuously write online tool
                                                  offset: Derived from the motion of
                                                  the V axis, the length 3 of the
                                                  active grinding wheel is compensated
                                                  in channel 1.
N60 V-0.05 G1 F0.01 G91                         ; Infeed motion for dressing, PUTFTOCF
                                                  is only effective in this block.
…
N… M30
```

Further information

General information about online TO

In the case of a continuous write (for each interpolation cycle), following activation of the evaluation function, each change is calculated additively in the wear memory (to prevent setpoint jumps).

In both cases: The online tool offset can act on each spindle and lengths 1, 2 **or** 3 of the wear parameters.

The lengths are assigned to the geometry axes with reference to the current working plane.

The spindle is assigned to the tool using tool data with GWPSON and TMON, unless this is the active grinding wheel.

An offset is always applied for the wear parameters for the current tool side or for the left-hand tool side on inactive tools.

Note

Where the offset is identical for several tool sides, the values should be transferred automatically to the second tool side by means of a chaining rule.

If online offsets are defined for a machining channel, the wear values for the current tool in this channel cannot be changed from the machining program or by means of an operator action.

The online tool offset is also applied with respect to the constant grinding wheel peripheral speed (GWPS) in addition to tool monitoring (TMON).

9.5 Activate 3D tool offsets (CUT3DC..., CUT3DF...)

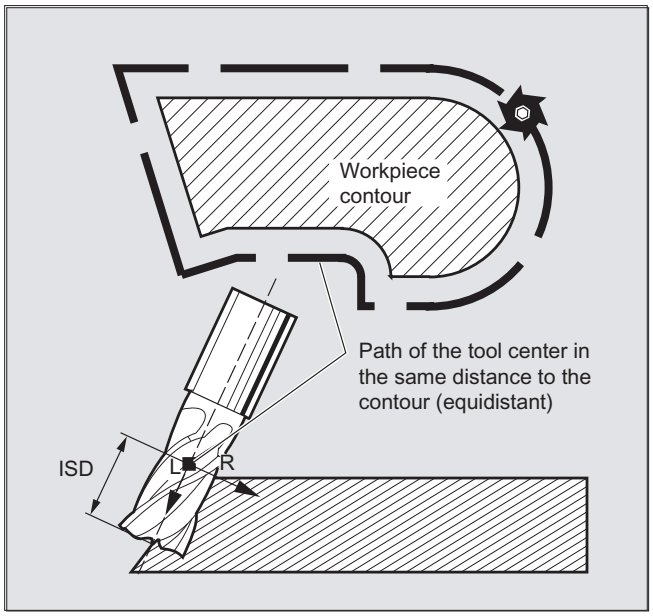
9.5.1 Activating 3D tool offsets (CUT3DC, CUT3DF, CUT3DFS, CUT3DFF, ISD)

Function

Tool orientation change is taken into account in tool radius compensation for cylindrical tools.

The same programming commands apply to 3D tool radius compensation as to 2D tool radius compensation. The left/right offset is specified in the direction of motion using G41/G42. The approach response is always controlled with NORM. The 3D radius compensation is only effective when 5-axis transformation is selected.

3D tool radius compensation is also called 5D tool radius compensation, because in this case five degrees of freedom are available for the orientation of the tool in space.



Difference between 2 1/2 D and 3D tool radius compensation

In 3D tool radius compensation tool orientation can be changed. With the 2 1/2D tool radius compensation, it is assumed that only a tool with constant orientation is being used.

Syntax

```
CUT3DC
CUT3DFS
CUT3DFF
CUT3DF
ISD=<value>
```

Meaning

CUT3DC	Activation of 3D radius offset for circumferential milling
CUT3DFS	D tool offset for face milling with constant orientation. The tool orientation is determined by G17 - G19 and is not influenced by frames.
CUT3DFF	D tool offset for face milling with constant orientation. The tool orientation is the direction defined by G17 - G19 and, in some case, rotated by a frame.
CUT3DF	D tool offset for face milling with orientation change (only with active 5-axes transformation).
G40 X... Y... Z...	To deactivate: Linear blockG0/G1 with geometry axes
ISD	Insertion depth

Note

The commands are modally effective and written in the same group asCUT2D and CUT2DF. The command is not deselected until the next movement in the current plane is performed. This always applies for G40 and is independent of the CUT command.

Intermediate blocks are permitted with 3D tool radius compensation. The definitions for 2 1/2D tool radius compensation apply.

Supplementary conditions

- **G450/G451 and DISC**

  A circular block is always inserted at out corners. G450/G451 have no significance. The DISC command is not evaluated.

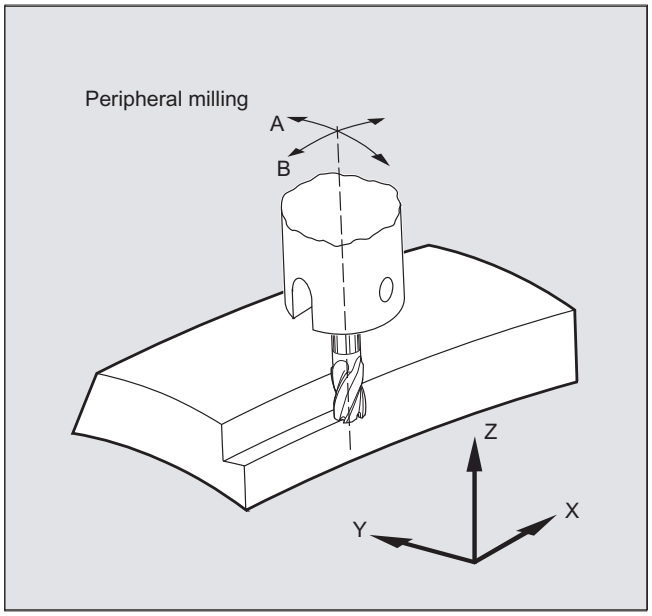
Example

```
Program code                    Comment
N10 A0 B0 X0 Y0 Z0 F5000
N20 T1 D1                       ; Tool call, call tool offset values.
N30 TRAORI(1)                   ; Transformation selection
N40 CUT3DC                      ; 3D tool radius compensation selection
N50 G42 X10 Y10                 ; Tool radius compensation selection
N60 X60
N70 …
```

9.5.2 3D tool offset peripheral milling, face milling

Circumferential milling

The type of milling used here is implemented by defining a path (guide line) and the corresponding orientation. In this type of machining, the shape of the tool on the path is not relevant. Especially the radius at the tool intervention point is decisive.

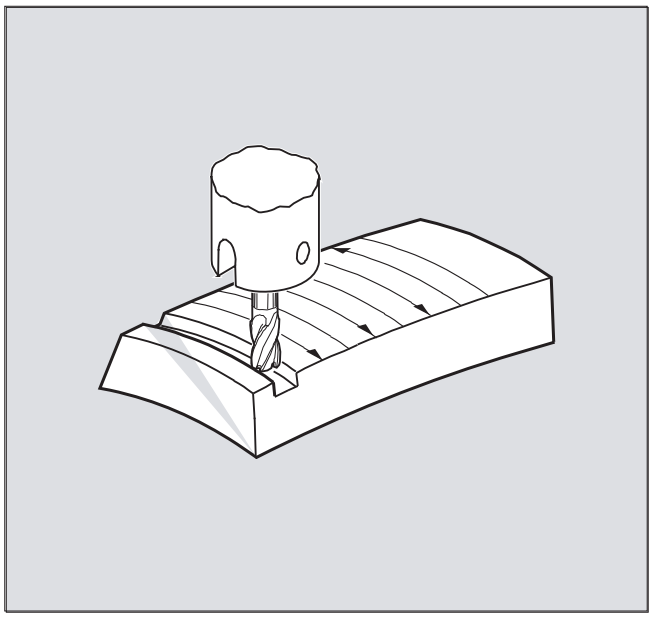


Note

The function 3D TRC is restricted to cylindrical tools.

Face milling

For this type of 3D milling, you will require the line-by-line description of the 3D paths on the workpiece surface. The tool shape and dimensions are taken into account in the calculations - which are normally performed in CAM. The post processor writes to the part program - in addition to NC blocks - to orientations (for active 5 axis transformation) and the G code for the required 3D tool offset. This means that the machine operator has the possibility of using tools that are slightly smaller - deviating from the tool used to calculate the NC paths.



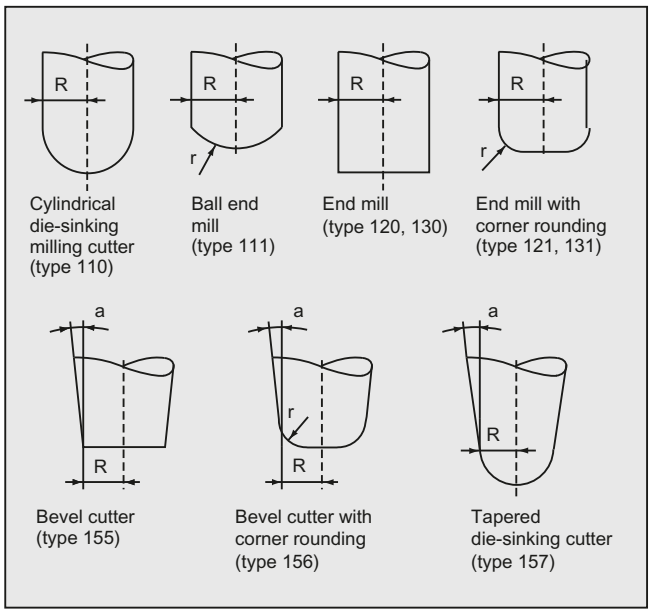
Example:

NC blocks were computed using a 10 mm milling tool. In this case, a milling tool diameter of 9.9 mm can be used for machining - whereby a modified roughness profile can be expended.

9.5.3 3D tool offset Tool shapes and tool data for face milling

Mill shapes, tool data

An overview of the tool shapes, which may be used for face milling operations and tool data limit values are listed in the following. The shape of the tool shaft is not taken into account. The effect of tool types 120 and 156 is identical.



If, in the NC program, a type number is specified that differs from that in the diagram, then the system automatically uses tool type 110 (cylindrical die-sinking milling tool). An alarm is output if the tool data limit values are violated.

Cutter type	Type No.	R	r	a
Cylindrical die-sinking milling cutter	110	> 0	-	-
Ball end mill	111	> 0	> R	-
End mill, angle head cutter	120, 130	> 0	-	-
End mill, angle head cutter with corner rounding	121, 131	> r	> 0	-
Bevel cutter	155	> 0	-	> 0
Bevel cutter with corner rounding	156	> 0	> 0	> 0
Tapered die-sinking cutter	157	> 0	-	> 0

R = shaft radius (tool radius)
r = corner radius
a = angle between the tool longitudinal axis and upper end of the torus surface
- = is not evaluated

Tool data	Tool parameters	
Tool dimensions	Geometry	Wear
R	$TC_DP6	$TC_DP15
r	$TC_DP7	$TC_DP16
a	$TC_DP11	$TC_DP20

Tool length offset

The tool tip is the reference point for length offset (intersection longitudinal axis/surface).

3D tool offset, tool change

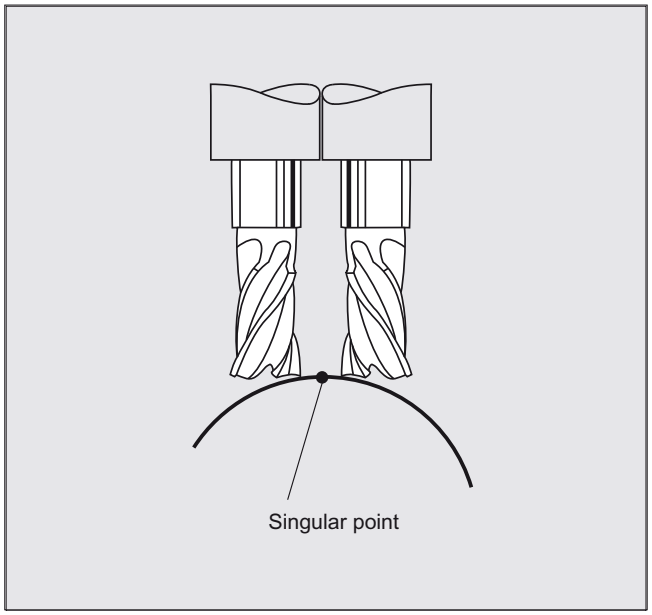
A new tool with modified dimensions (R, r, a) or a different shaft may only be specified with the programming of `G41` or `G42` (transition `G40` to `G41` or `G42`, reprogramming of `G41` or `G42`). This rule does not apply to any other tool data, e.g., tool lengths, so that tools can be loaded without reprogramming `G41` or `G42`.

9.5.4 3D tool offset Offset on the path, path curvature, insertion depth (CUT3DC, ISD)

Function

Offset on the path

With respect to face milling, it is advisable to examine what happens when the contact point "jumps" on the tool surface as shown in the example on the right where a convex surface is being machined with a vertically positioned tool. The application shown in the example should be regarded as a borderline case.



This borderline case is monitored by the controller that detects abrupt changes in the machining point on the basis of angular approach motions between the tool and normal surface vectors. The controller inserts linear blocks at these positions so that the motion can be executed.

These linear blocks are calculated on the basis of permissible angular ranges for the side angle stored in the machine data. The system outputs an alarm if the limit values stored in the machine data are violated.

Path curvature

Path curvature is not monitored. In such cases, it is also advisable to use only tools of a type that do not violate the contour.

Insertion depth (ISD)

Insertion depth ISD is only evaluated when 3D tool radius compensation is active.

Program command `ISD` (insertion depth) is used to program the tool insertion depth for circumferential milling operations. This makes it possible to change the position of the machining point on the outer surface of the tool.

Syntax

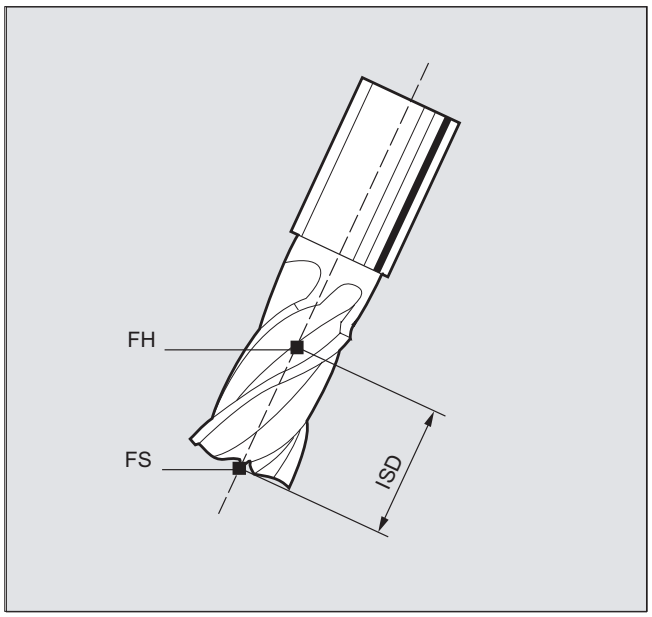
3D tool offset circumferential milling
```
CUT3DC
ISD=<value>
```

Meaning

`CUT3DC`	Activate 3D tool offset for circumferential milling, e.g. for pocket milling with oblique side walls.
`ISD`	The clearance (`<value>`) between the milling tool tip (FS) and the milling tool construction point (FH) are specified using the command `ISD`.

Milling tool reference point

The milling tool reference point (FH) is obtained by projecting the programmed machining point onto the tool axis.



Further Information

Pocket milling with inclined side walls for circumferential milling with CUT3DC

In this 3D tool radius compensation, a deviation of the mill radius is compensated by infeed toward the normals of the surface to be machined. The plane, in which the milling tool face is located, remains unchanged if the insertion depth `ISD` has remained the same. For example, a milling tool with a smaller radius than a standard tool would not reach the pocket base, which is also the limitation surface. For automatic tool infeed, this limitation surface must be known to the control, see section "3D circumferential milling with limitation surfaces".

For additional information on collision monitoring, refer to:
References:
Programming Manual Basics; Chapter "Tool offsets".

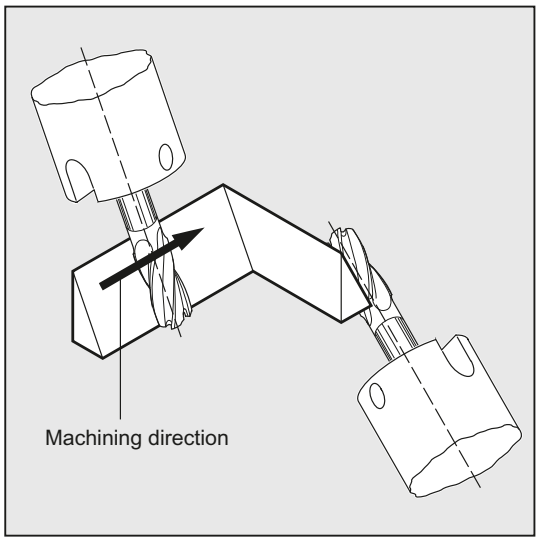
9.5.5 3D tool offset Inside/outside corners and intersection procedure (G450/G451)

Function

Inside corners/outside corners

Inside and outside corners are handled separately. The terms inner corner and outer corner are dependent on the tool orientation.

When the orientation changes at a corner, for example, the corner type may change while machining is in progress. Whenever this occurs, the machining operation is aborted with an error message.



Syntax

```
G450
G451
```

Meaning

`G450`	Transition circle (tool travels round workpiece corners on a circular path)
`G451`	Intersection of equidistant paths (tool backs off from the workpiece corner)

Further Information

Intersection procedure for 3D compensation

With 3D circumferential milling, G code `G450/G451` is now evaluated i.e. the point of intersection of the offset curves can be approached. Up to SW 4 a circle was always inserted at the outside corners. The intersection procedure is especially advantageous for 3D programs typically generated by CAD. These often consist of short straight blocks (to approximate smooth curves), where the transitions between adjacent blocks are almost tangential.

Up to now, with tool radius compensation on the outside of the contour, circles were generally inserted to circumnavigate the outside corners. These blocks can be very short with almost tangential transitions, resulting in undesired drops in velocity.

In these cases, analog to the 2 ½ D radius compensation, the two curves involved are extended; the intersection of both extended curves is approached.

The intersection is determined by extending the offset curves of the two participating blocks and defining the intersection of the two blocks at the corner in the plane perpendicular to the tool orientation. If there is not such intersection, the corner is handled as before – i.e. a circle is inserted.

For more information on the intersection procedure, see:
References:
Function Manual, Special Functions; 3D Tool Radius Compensation (W5)

9.5.6 3D tool offset 3D circumferential milling with limitation surfaces

Adaptation of 3D circumferential milling to the conditions for CAD programs

NC programs generated by CAD systems usually approximate the center path of a standard tool with a large number of short linear blocks. To ensure that the blocks of many part contours generated in this way map the original contour as precisely as possible, it is necessary to make certain changes to the part program.

Important information, which would be required to achieve optimum compensation, that is no longer available in the part program must be replaced using suitable measures. Here are some typical methods to compensate critical transitions, either directly in the part program or when determining the real contour (e.g. using tool infeed).

Applications

In addition to the typical applications for which instead of the standard tool, a real tool describes the center-point path, cylindrical tools with 3D tool compensation are also described. In this case, the programmed path refers to the contour on the machining surface. The associated limitation surface is independent of the tool. Just the same as for conventional tool radius compensation, the entire radius is used to calculate the perpendicular offset to the limitation surface.

9.5.7 3D tool offset: Taking into consideration a limitation surface (CUT3DCC, CUT3DCCD)

Function

3D circumferential milling with real tools

In 3D circumferential milling with a continuous or constant change in tool orientation, the tool center point path is frequently programmed for a defined standard tool. Because in practice suitable standard tools are often not available, a tool that does not deviate too much from a standard tool can be used.

`CUT3DCCD` takes account of a limitation surface for a real differential tool that the programmed standard tool would define. The NC program defines the center-point path of a standard tool.

`CUT3DCC` with the use of cylindrical tools takes account of a limitation surface that the programmed standard tool would have reached. The NC program defines the contour on the machining surface.

Syntax

```
CUT3DCCD
CUT3DCC
```

Meaning

`CUT3DCCD`	Activation of the 3D tool offset for the circumferential milling with limitation surfaces with a differential tool on the tool center point path: Infeed to the limitation surface.
`CUT3DCC`	Activation of the 3D tool offset for circumferential milling with limitation surfaces with 3D radius compensation: Contour on the machining surface

Note

Tool radius compensation with G41, G42

If tool radius compensation with `G41`, `G42` is programmed when `CUT3DCCD` or `CUT3DCC` is active, the option "orientation transformation" must also be active.

Standard tools with corner rounding

Corner rounding with a standard tool is defined by the tool parameter `$TC_DP7`. Tool parameter `$TC_DP16` describes the deviation of the corner rounding of the real tool compared with the standard tool.

Example

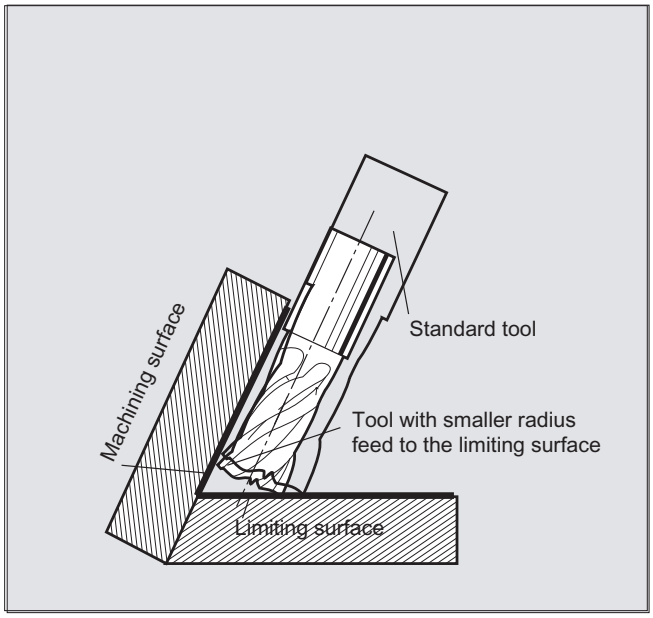
Tool dimensions of a toroidal miller with reduced radius as compared with the standard tool.

Tool type	R = shank radius	r = corner radius
Standard tool with corner rounding	R = $TC_DP6	r = $TC_DP7
Real tool with corner rounding: Tool types 121 and 131 torus milling tool (shaft milling tool)	R' = $TC_DP6 + $TC_DP15 + OFFN	r' = $TC_DP7 + $TC_DP16
In this example, both $TC_DP15 + OFFN and $TC_DP16 are negative. The tool type ($TC_DP1) is evaluated.		
Only cutter types with cylindrical shank (cylinder or end mill), toroidal millers (types 121 and 131) and, in the limit case, cylindrical die mills (type 110) are permitted.	For these approved cutter types, the corner radius r is identical to the shank radius R. All other permitted tool types are interpreted as cylindrical cutters and the dimensions specified for the corner rounding are not evaluated.	
All tool types of the numbers 1 - 399, with the exception of the numbers 111 and 155 to 157, are permitted.		

Further Information

Tool center point path with infeed up to the limitation surface CUT3DCCD

If a tool with a smaller radius than the appropriate standard tool is used, machining is continued using a milling tool, which is infed in the longitudinal direction until it reaches the bottom (base) of the pocket. The tool removes as much material from the corner formed by the machining surface and limitation surface. This involves a machining type combining circumferential and face milling. Analog to a tool with lower radius, for a tool with increased radius, the infeed is in the opposite direction.



Contrary to all other tool offsets of G code group 22, tool parameter `$TC_DP6` specified for `CUT3DCCD` does not influence the tool radius and the resulting compensation.

The compensation offset is the sum of:

- The wear value of the tool radius (tool parameter `$TC_DP15`)
- and a tool offset `OFFN` programmed to calculate the perpendicular offset to the limitation surface.

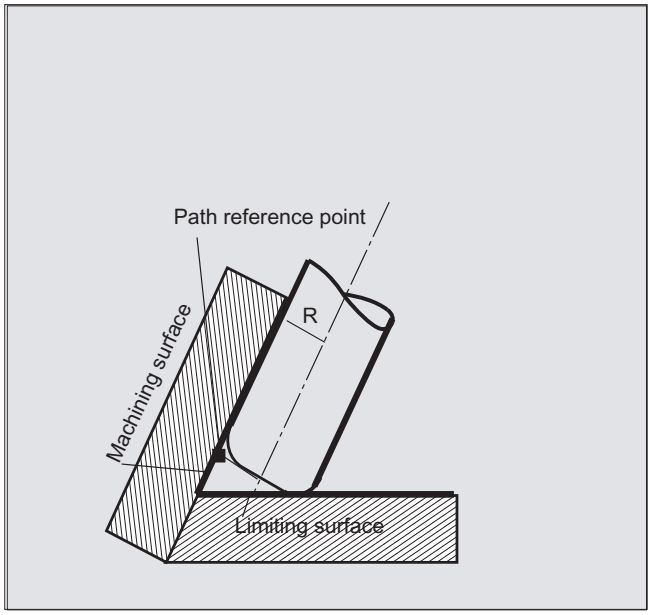
The generated part program does not specify whether the surface to be machined is to the right or left of the path. It is therefore assumed that the radius is a positive value and the wear value of the original tool is a negative value. A negative wear value always describes a tool with a lower diameter.

Using cylindrical tools

When cylindrical tools are used, infeed is only necessary if the machining surface and the surface of limitation form an acute angle (less than 90 degrees). If a torus milling tool (cylinder with rounded corners) is used, tool infeed in the longitudinal direction is required for both acute and obtuse angles.

3D radius compensation with CUT3DCC, contour on the machining surface

If CUT3DCC is active with a torus milling tool, the programmed path refers to a fictitious cylindrical milling tool having the same diameter. The resulting path reference point is shown in the following diagram for a torus milling tool.



The angle between the machining and limitation surfaces may change from an acute to an obtuse angle and vice versa even within the same block.

The tool actually being used may either be larger or smaller than the standard tool. However, the resulting corner radius must not be negative and the sign of the resulting tool radius must be kept.

For CUT3DCC, the NC part program refers to contour on the machining surface. As for conventional tool radius compensation, the total tool radius is used that comprises the sum of:

- Tool radius (tool parameter $TC_DP6)
- Wear value (tool parameter $TC_DP15)
- and a tool offset OFFN programmed to calculate the perpendicular offset to the limitation surface.

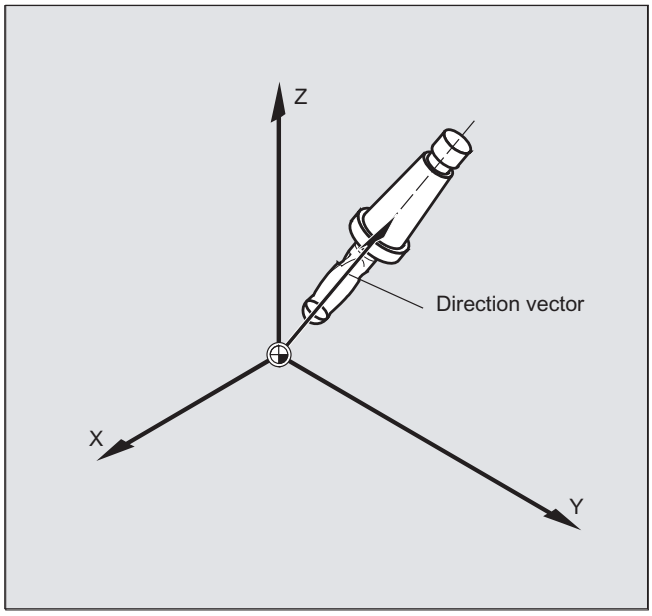
The position of the limitation surface is determined from the difference between these two values:

- Dimensions of the standard tool
- Tool radius (tool parameter $TC_DP6)

9.6 Tool orientation (ORIC, ORID, OSOF, OSC, OSS, OSSE, ORIS, OSD, OST)

Function

The term tool orientation describes the geometric alignment of the tool in space. The tool orientation on a 5-axis machine tool can be set by means of program commands.



Orientation rounding movements activated with `OSD` and `OST` are formed differently depending on the type of interpolation for tool orientation.

If vector interpolation is active, the smoothed orientation characteristic is also interpolated using vector interpolation. On the other hand, if rotary axis interpolation is active, the orientation is smoothed directly using rotary axis movements.

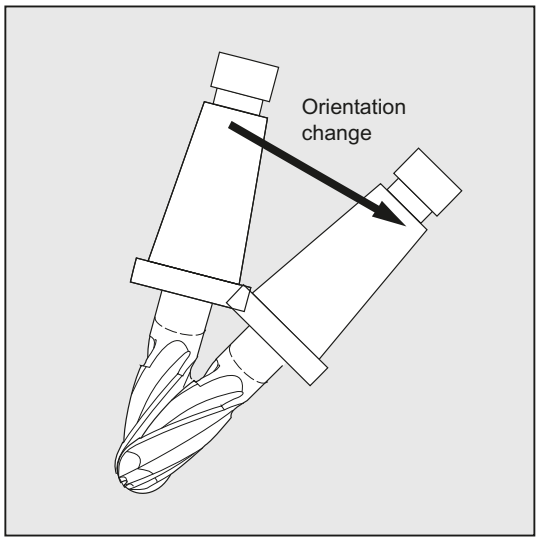
Programming

Programming a orientation change:

A change in tool orientation can be programmed by:

- Direct programming of rotary axes `A`, `B`, `C` (rotary axis interpolation)
- Euler or RPY angle
- Direction vector (vector interpolation by specifying `A3` or `B3` or `C3`)
- `LEAD/TILT` (face milling)

The reference coordinate system is either the machine coordinate system (`ORIMKS`) or the current workpiece coordinate system (`ORIWKS`).



Programming tool orientation:

Command	Meaning
ORIC:	Orientation and path movement in parallel
ORID:	Orientation and path movement consecutively
OSOF:	No orientation smoothing
OSC:	Orientation constantly
OSS:	Orientation smoothing only at beginning of block
OSSE:	Orientation smoothing at beginning and end of block
ORIS:	Velocity of the orientation change with orientation smoothing activated in degrees per mm (valid for OSS and OSSE)
OSD:	Smoothing of orientation by specifying smoothing distance with setting data: SD42674 $SC_ORI_SMOOTH_DIST
OST:	Smoothing of orientation by specifying angular tolerance in degrees for vector interpolation with setting data: SD42676 $SC_ORI_SMOOTH_TOL With rotary axis interpolation, the specified tolerance is assumed to be the maximum variance of the orientation axes.

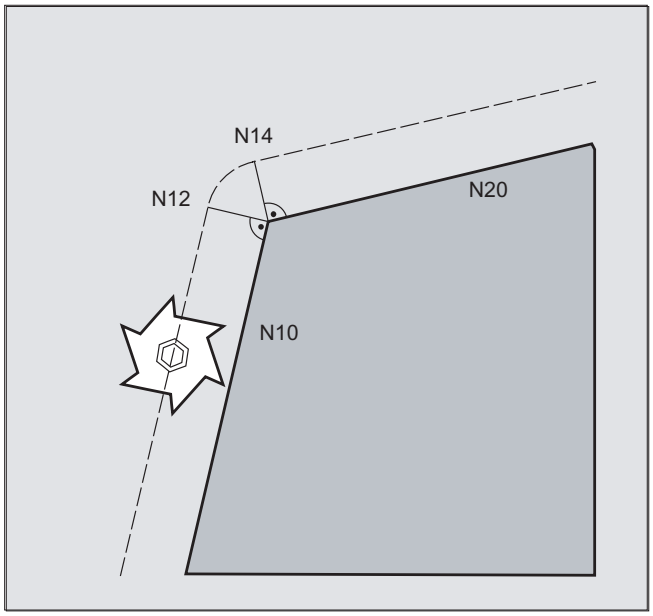
Note

All commands for smoothing the tool orientation (OSOF, OSC, OSS, OSSE, OSD, and OST) are summarized in G function group 34. They are modal; in other words, only one of these commands can ever be effective at the same time.

Examples

Example 1: ORIC

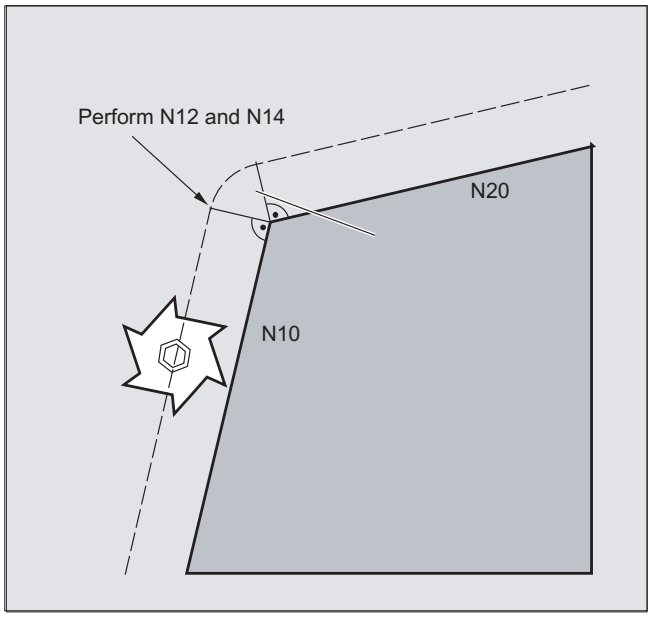
If `ORIC` is active and there are two or more blocks with changes in orientation (e.g.`A2=... B2=... C2=...`) programmed between traversing blocks `N10` and `N20`, then the inserted circle block is distributed among these intermediate blocks according to the absolute changes in angle.




```
Program code                    Comment
ORIC
N8 A2=… B2=… C2=…
N10 X… Y… Z…
N12 C2=… B2=…                   ; The circle block inserted at the external corner is
N14 C2=… B2=…                     distributed between N12 and N14, corresponding to
                                  the change in orientation. The circular motion and
                                  the orientation change are executed in parallel.
N20 X =…Y=… Z=… G1 F200
```

Example 2: ORID

If `ORID` is active, then all blocks between the two traversing blocks are executed at the end of the first traversing block. The circle block with constant orientation is executed immediately before the second traversing block.



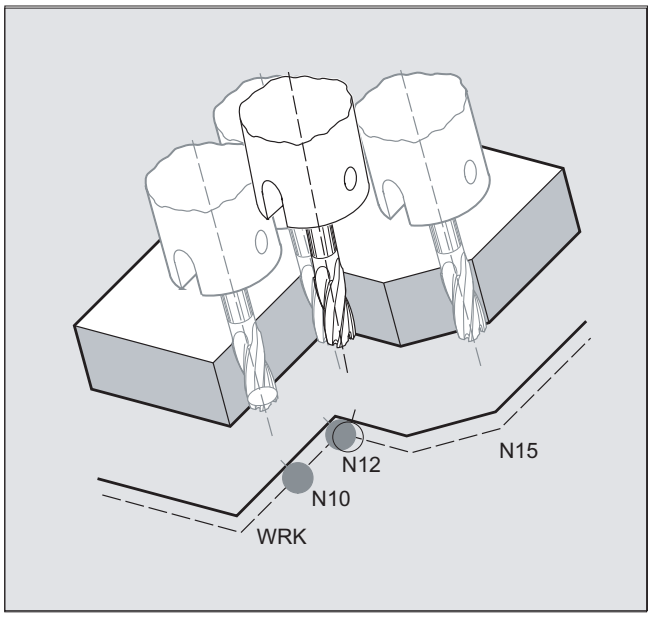
Program code	Comment
ORID	
N8 A2=… B2=… C2=…	
N10 X… Y… Z…	
N12 A2=… B2=… C2=…	; The N12 and N14 blocks are executed at the end of N10. The circle block is then executed with the actual orientation.
N14 M20	; Help functions, etc.
N20 X… Y… Z…	

Note

The method which is used to change orientation at an outer contour is determined using the program command that is active in the first traversing block of an outer corner.

Without change in orientation: If the orientation is not changed at the block boundary, the cross-section of the tool is a circle, which touches both of the contours.

Example 3: Changing the orientation at an inner corner



Program code

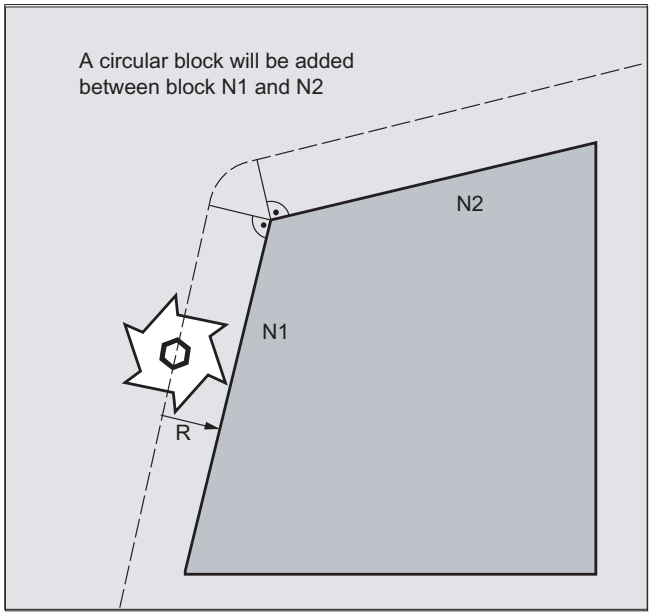
```
ORIC
N10 X …Y… Z… G1 F500
N12 X …Y… Z… A2=… B2=… C2=…
N15 X …Y… Z… A2=… B2=… C2=…
```

Further Information

Behavior at outer corners

A circle block with the radius of the cutter is always inserted at an outside corner.

The `ORIC` and `ORID` program commands are used to determine whether changes in orientation programmed between block `N1` and `N2` are executed before the inserted circle block is processed or at the same time.



If an orientation change is required at outside corners, this can be performed either at the same time as interpolation or separately together with the path movement.

When ORID is programmed, the inserted blocks are executed first without path motion. The circle block generating the corner is inserted immediately before the second of the two traversing blocks.

If several orientation blocks are inserted at an external corner and ORIC is selected, the circular motion is distributed among the individual inserted blocks according to the absolute values of the orientation changes.

Smoothing orientation with OSD or OST

When blending with G642, the maximum variance for the contour axes and orientation axes cannot vary greatly. The smaller tolerance of the two determines the type of smoothing motion and/or angular tolerance to smooth the orientation characteristic relatively strongly without having to accept higher contour deviations.

OSD and OST can be activated to "generously" smooth very slight deviations from the orientation characteristics with a specified smoothing distance and angular tolerance without serious contour deviations.

Note

Unlike the process of rounding the contour (and orientation characteristics) with G642, when rounding the orientation with OSD and/or OST, a separate block is not formed, instead the rounding movement is added directly to the programmed original blocks.

With OSD and/or OST, block transitions cannot be rounded if there is a change in the type of interpolation for tool orientation (vector → rotary axis, rotary axis → vector). These block transitions can if necessary be rounded with the standard rounding functions G641, G642 and G643.

9.7 Free assignment of D numbers, cutting edge numbers

9.7.1 Free assignment of D numbers, cutting edge numbers (CE address)

D number

The D numbers can be used as contour numbers. You can also address the number of the cutting edge via the address CE. You can use the system variable $TC_DPCE to describe the cutting edge number.

Default: compensation no. == tool edge no.

Machine data are used to define the maximum number of D numbers (cutting edge numbers) and the maximum number of cutting edges per tool (→ machinery construction OEM). The following commands are only practical if the maximum cutting edge number (MD18105) was specified to be greater than the number of cutting edges per tool (MD18106). See machine manufacturer's specifications.

Note

In addition to relative D number allocation, the D numbers can also be assigned as "flat" or "absolute" D numbers (1-32000) without a reference to a T number (within the "Flat D number structure" function).

References

Function Manual Basic Functions; Tool Offset (W1)

9.7.2 Free assignment of D numbers: Checking D numbers (CHKDNO)

Function

Using the CKKDNO command, you can check whether the existing D numbers were uniquely assigned. The D numbers of all tools defined within a TO unit may not occur more than once. No allowance is made for replacement tools.

Syntax

```
state=CHKDNO(Tno1,Tno2,Dno)
```

Meaning

`state`	=TRUE:	The D numbers are assigned uniquely to the checked areas.
	= FALSE:	There was a D number collision or the parameters are invalid. Tno1, Tno2 and Dno return the parameters that caused the collision. These data can now be evaluated in the part program.
`CHKDNO(Tno1,Tno2)`	All D numbers of the part specified are checked.	
`CHKDNO(Tno1)`	All D numbers of Tno1 are checked against all other tools.	
`CHKDNO`	All D numbers of all tools are checked against all other tools.	

9.7.3 Free assignment of D numbers: Rename D numbers (GETDNO, SETDNO)

Function

You must assign unique D numbers. Two different cutting edges of a tool must not have the same D number.

GETDNO

This command returns the D number of a particular cutting edge (ce) of a tool with tool number t. If no D number exists for the entered parameters, d=0 will be set. If the D number is invalid, a value greater than 32000 is returned.

SETDNO

This command assigns the value d of the D number to a cutting edge ce of tool t. The result of this statement is returned via state (TRUE or FALSE). If there is no data block for the specified parameter, the value FALSE is returned. Syntax errors generate an alarm. The D number cannot be set explicitly to 0.

Syntax

```
d = GETDNO (t,ce)

state = SETDNO (t,ce,d)
```

Meaning

`d`	D number of the tool edge
`t`	T number of the tool
`ce`	Cutting edge number (CE number) of the tool
`state`	Indicates whether the command could be executed (TRUE or FALSE).

Example for renaming a D number

Programming	Comment
`$TC_DP2[1.2]=120`	;
`$TC_DP3[1,2] = 5.5`	;
`$TC_DPCE[1,2] = 3`	; Cutting edge number CE
`...`	;
`N10 def int DNoOld, DNoNew = 17`	;
`N20 DNoOld = GETDNO(1,3)`	;
`N30 SETDNO(1,3,DNoNew)`	;

The new D value 17 is then assigned to cutting edge CE=3. Now the data for the cutting edge are addressed via D number 17; both via the system variables and in the programming with the NC address.

9.7.4 Free assignment of D numbers: Determine T number to the specified D number (GETACTTD)

Function

You determine the T number associated with an absolute D number using the `GETACTTD` command. There is not check for uniqueness. If several D numbers within a TO unit are the same, the T number of the first tool found in the search is returned. This command is not suitable for use with "flat" D numbers, because the value "1" is always returned in this case (no T numbers in database).

Syntax

```
status=GETACTTD(Tnr,Dnr)
```

Meaning

`Dno`	D number for which the T number shall be searched.	
`Tno`	T number found	
`status`	Value:	Meaning:
	0	The T number has been found. Tno contains the value of the T number.
	-1	No T number exists for the specified D number; Tno=0.
	-2	The D number is not absolute. Tno receives the value of the first found tool that contains the D number with the value Dno.
	-5	The function was not able to be executed for another reason.

9.7.5 Free assignment of D numbers: Invalidate D numbers (DZERO)

Function

The DZERO command is used for support during retooling. Compensation data sets tagged with this command are no longer verified by the CHKDNO command. These data sets can be accessed again by setting the D number once more with SETDNO.

Syntax

```
DZERO
```

Significance

DZERO	Marks all D numbers of the TO unit as invalid.

9.8 Toolholder kinematics

Requirements

A toolholder can only orientate a tool in all possible directions in space if

- Two rotary axes V1 and V2 are present.
- The rotary axes are mutually orthogonal.
- The tool longitudinal axis is perpendicular to the second rotary axis V2.

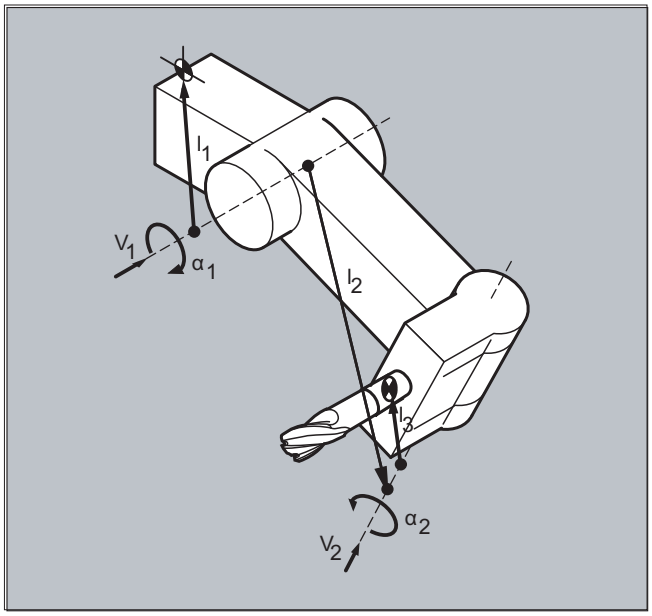
In addition, the following requirement is applicable to machines for which all possible orientations have to be settable:

- The tool longitudinal axis must be perpendicular to the first rotary axis V1.

Function

The toolholder kinematics with a maximum of two rotary axes v_1 or v_2 are defined using the 17 system variables $TC_CARR1[m] to $TC_CARR17[m]. The description of the toolholder consists of:

- The vectoral distance from the first rotary axis of the toolholder `I1`, the vectoral distance from the first rotary axis to the second rotary axis `I2`, the vectoral distance from the second rotary axis to the reference point of the tool `I3`.
- The direction vectors of both rotary axes `V1`, `V2`.
- The angles of rotation α1, α2 around the two axes. The rotation angles are counted in viewing direction of the rotary axis vectors, positive, in clockwise direction of rotation.



For machines with **resolved kinematics** (both the tool and the part can rotate), the system variables have been extended with the entries $TC_CARR18[m] to $TC_CARR23[m].

Parameters

Function of the system variables for orientable toolholders			
Designation	**x component**	**y component**	**z component**
l_1 offset vector	$TC_CARR1[m]	$TC_CARR2[m]	$TC_CARR3[m]
l_2 offset vector	$TC_CARR4[m]	$TC_CARR5[m]	$TC_CARR6[m]
v_1 rotary axis	$TC_CARR7[m]	$TC_CARR8[m]	$TC_CARR9[m]
v_2 rotary axis	$TC_CARR10[m]	$TC_CARR11[m]	$TC_CARR12[m]
α_1 angle of rotation α_2 angle of rotation	$TC_CARR13[m] $TC_CARR14[m]		
l_3 offset vector	$TC_CARR15[m]	$TC_CARR16[m]	$TC_CARR17[m]

Extensions of the system variables for orientable toolholders			
Designation	**x component**	**y component**	**z component**
l_4 offset vector	$TC_CARR18[m]	$TC_CARR19[m]	$TC_CARR20[m]
Axis identifier Rotary axis v_1 Rotary axis v_2	Axis identifier of the rotary axes v_1 and v_2 (initialized with zero) $TC_CARR21[m] $TC_CARR22[m]		
Kinematic type **T**ool **P**art **M**ixed mode	$TC_CARR23[m]		
	Kinematics type T ->	Kinematics type P ->	Kinematics type M
	Only the tool can rotate (default).	Only the part can rotate	Part and tool can rotate
Offset of the Rotary axis v_1 Rotary axis v_2	Angle in degrees of the rotary axes v_1 and v_2 on assuming the initial setting $TC_CARR24[m] $TC_CARR25[m]		
Angle offset of the rotary axis v_1 Rotary axis v_2	Offset of the Hirth tooth system in degrees for rotary axes v_1 and v_2 $TC_CARR26[m] $TC_CARR27[m]		
Angle increment v_1 rotary axis v_2 rotary axis	Offset of the Hirth tooth system in degrees for rotary axes v_1 and v_2 $TC_CARR28[m] $TC_CARR29[m]		
Min. position Rotary axis v_1 Rotary axis v_2	Software limit for the minimum position of the rotary axes v_1 and v_2 $TC_CARR30[m] $TC_CARR31[m]		
Max. position Rotary axis v_1 Rotary axis v_2	Software limits for the maximum position of the rotary axes v_1 and v_2 $TC_CARR32[m] $TC_CARR33[m]		
Toolholder name	A toolholder can be given a name instead of a number. $TC_CARR34[m]		
User: Axis name 1 Axis name 2 Identifier **Position**	Intended use in user measuring cycles $TC_CARR35[m] $TC_CARR36[m] $TC_CARR37[m]		
	$TC_CARR38[m]	$TC_CARR39[m]	$TC_CARR40[m]
Fine offset	Parameters that can be added **to the values in the basic parameters**.		
l_1 offset vector	$TC_CARR41[m]	$TC_CARR42[m]	$TC_CARR43[m]
l_2 offset vector	$TC_CARR44[m]	$TC_CARR45[m]	$TC_CARR46[m]
l_3 offset vector	$TC_CARR55[m]	$TC_CARR56[m]	$TC_CARR57[m]
l_4 offset vector	$TC_CARR58[m]	$TC_CARR59[m]	$TC_CARR60[m]
v_1 rotary axis	$TC_CARR64[m]		
v_2 rotary axis	$TC_CARR65[m]		

Note

Explanations of parameters

"m" specifies the number of the toolholder to be programmed.

$TC_CARR47 to $TC_CARR54 and $TC_CARR61 to $TC_CARR63 are not defined and produce an alarm if read or write access is attempted.

The start/endpoints of the distance vectors on the axes can be freely selected. The rotation angles $\alpha 1$, $\alpha 2$ about the two axes are defined in the initial state of the toolholder by 0°. In this way, the kinematics of a toolholder can be programmed for any number of possibilities.

Toolholders with only one or no rotary axis at all can be described by setting the direction vectors of one or both rotary axes to zero.
With a toolholder without rotary axis the distance vectors act as additional tool offsets whose components cannot be affected by a change of machining plane (G17 to G19).

Parameter extensions

Parameters of the rotary axes

The system variables have been extended by the entries $TC_CARR24[m] to $TC_CARR33[m] and described as follows:

Offset of rotary axes v_1, v_2	Changing the position of the rotary axis v_1 or v_2 for the initial setting of the oriented toolholder.
The **angle offset/angle increment** of the rotary axes v_1, v_2	The offset or the angle increment of the Hirth tooth system of the rotary axes v_1 and v_2. Programmed or calculated angle is rounded up to the next value that results from phi = s + n * d when n is an integer.
The minimum and maximum position of the rotary axes v_1, v_2	The minimum and maximum position of the rotary axis limit angle (software limit) of the rotary axes v1 and v2.

Parameters for the user

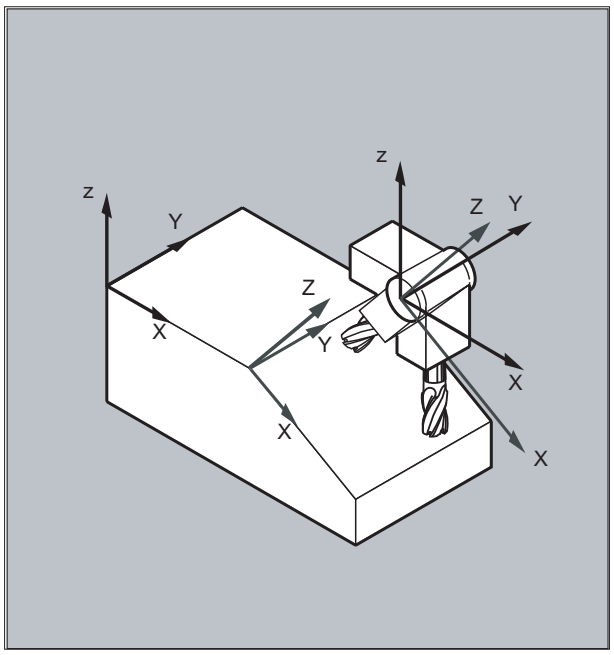
$TC_CARR34 to $TC_CARR40 contain parameters that are freely available to users and up to SW 6.4 were as standard, not further evaluated within the NCK or had no significance.

Fine offset parameters

$TC_CARR41 to $TC_CARR65 include fine offset parameters that can be added to the values in the basis parameters. The fine offset value assigned to a basic parameter is obtained when the value 40 is added to the parameter number.

Example

The toolholder used in the following example can be fully described by a rotation around the Y axis.



Program code	Comment
N10 $TC_CARR8[1]=1	; Definition of the Y component of the first rotary axis of toolholder 1.
N20 $TC_DP1[1,1] = 120	; Definition of a shaft miller.
N30 $TC_DP3[1,1]=20	; Definition of a shaft miller, 20 mm long.
N40 $TC_DP6[1,1]=5	; Definition of a shaft miller with 5 mm radius.
N50 ROT Y37	; Frame definition with 37° rotation around the Y axis.
N60 X0 Y0 Z0 F10000	; Approach starting position.
N70 G42 CUT2DF TCOFR TCARR=1 T1 D1 X10	; Set radius compensation, tool length compensation in rotated frame, select toolholder 1, tool 1.
N80 X40	; Perform machining under a rotation of 37°.
N90 Y40	
N100 X0	
N110 Y0	
N120 M30	

Further information

Resolved kinematics

For machines with resolved kinematics (both the tool as well as the workpiece can be rotated), the system variables have been expanded by the entries `$TC_CARR18[m]` up to `$TC_CARR23[m]` and are described as follows:

The rotatable tool table consisting of:

- The vectorial clearance of the second rotary axis `V2` to the reference point of a tool table that can be rotated `I4` of the third rotary axis.

The rotary axes consisting of:

- The two channel identifiers for the reference of the rotary axes `V1`and `V2`, whose position is, when required, accessed to determine the orientation of the toolholder that can be orientated.

The type of kinematics with one of the values T, P or M:

- Kinematics type T: Only tool can rotate.
- Kinematics type P: Only part can rotate.
- Kinematics type M: Tool and part can rotate.

Clearing the toolholder data

Data of all toolholder data sets can be deleted using `$TC_CARR1[0]=0`.

The kinematic type `$TC_CARR23[T]=T` must be assigned with one of the three permissible upper or lower case letters (T,P,M) and for this reason, should not be deleted.

Changing the toolholder data

Each of the described values can be modified by assigning a new value in the part program. Any character other than T, P or M results in an alarm when an attempt is made to activate the toolholder that can be orientated.

Reading the toolholder data

Each of the described values can be read by assigning it to a variable in the part program.

Fine offsets

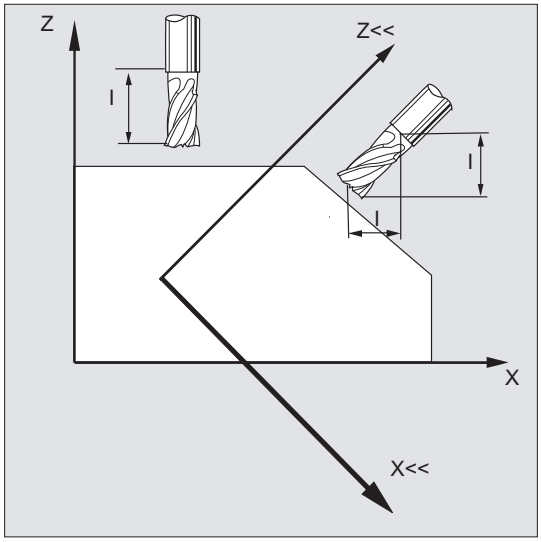
An illegal fine offset value is only detected if a toolholder that can be orientated is activated, which contains such a value and at the same time setting data
SD42974 $SC_TOCARR_FINE_CORRECTION = TRUE.

The maximum permissible fine offset is limited to a permissible value in the machine data.

9.9 Tool length compensation for orientable toolholders (TCARR, TCOABS, TCOFR, TCOFRX, TCOFRY, TCOFRZ)

Function

When the spatial orientation of the tool changes, its tool length components also change.



After a reset, e.g. through manual setting or change of the toolholder with a fixed spatial orientation, the tool length components also have to be determined again. This is performed using the TCOABS and TCOFR path commands.

For a toolholder of an active frame that can be orientated, when selecting the tool with TCOFRZ, TCOFRY and TCOFRX, it is possible to define the direction in which the tool should point.

Syntax

```
TCARR=[<m>]
TCOABS
TCOFR
TCOFRZ
TCOFRY
TCOFRX
```

Meaning

TCARR=[<m>]:	Request toolholder with the number "m"
TCOABS:	Determine tool length components from the orientation of the current toolholder
TCOFR:	Determine tool length components from the orientation of the active frame

TCOFRZ:	Orientable toolholder from active frame with a tool pointing in the Z direction
TCOFRY:	Orientable toolholder from active frame with a tool pointing in the Y direction
TCOFRX:	Orientable toolholder from active frame with a tool pointing in the X direction

Further Information

Determine tool length compensation from the orientation of the toolholder (TCOABS)

TCOABS calculates the tool length compensation from the current orientation angles of the toolholder; saved in the system variables $TC_CARR13 and $TC_CARR14.

For a definition of toolholder kinematics with system variables, see "Toolholder kinematics (Page 427)".

In order to make a new calculation of the tool length compensation when frames are changed, the tool has to be selected again.

Tool direction from active frame

The toolholder with orientation capability is set so that the tool points in the following directions.

- with TCOFR or TCOFRZ in the Z direction
- with TCOFRY in the Y direction
- with TCOFRX in the X direction

The tool length compensation is re-calculated when changing over between TCOFR and TCOABS.

Request toolholder (TCARR)

With TCARR, the toolholder number m is requested with its geometry data (compensation memory).

With m=0, the active toolholder is deselected.

The geometry data of the toolholder only become active after a tool is called. The selected tool remains active after a toolholder change has taken place.

The current geometry data for the toolholder can also be defined in the part program via the corresponding system variables.

Recalculation of tool length compensation (TCOABS) for a frame change

In order to make a new calculation of the tool length compensation when frames are changed, the tool has to be selected again.

Note

The tool orientation must be manually adapted to the active frame.

When the tool length compensation is calculated, the angle of rotation of the toolholder is calculated in an intermediate step. With toolholders with two rotary axes, there are generally two sets of rotation angles, which can be used to adapt the tool orientation to the active frame; therefore, the rotation angle values stored in the system variables must at least correspond approximately to the mechanically set rotation angles.

Note

Tool orientation

It is not possible for the control to check whether the rotation angles calculated by means of the frame orientation are settable on the machine.

If the rotary axes of the toolholder are arranged such that the tool orientation calculated by means of the frame orientation cannot be reached, then an alarm is output.

The combination of tool precision compensation and the functions for tool length compensation on movable toolholders is not permissible. If both functions are called simultaneously, an error message is issued.

The TOFRAME function allows a frame to be defined on the basis of the direction of orientation of the selected toolholder. For more information please refer to chapter "Frames".

When orientation transformation is active (3, 4 or 5-axis transformation), it is possible to select a toolholder with an orientation deviating from the zero position without causing output of an alarm.

Transfer parameter from standard and measuring cycles

For the transfer parameter of standard and measuring cycles, the following defined value ranges apply.

For angular value, the value range is defined as follows:

- Rotation around 1st geometry axis: -180 degrees to +180 degrees
- Rotation around 2nd geometry axis: -90 degrees to +90 degrees
- Rotation around 3rd geometry axis: -180 degrees to +180 degrees

Refer to Chapter Frames, "Programmable rotation (ROT, AROT, RPL)".

Note

When transferring angular values to a standard or measuring cycle, the following should be carefully observed:

Values less than the calculation resolution of the NC should be rounded-off to zero!

The calculation resolution of the NC for angular positions is defined in the machine data:

MD10210 $MN_INT_INCR_PER_DEG

9.10 Online tool length compensation (TOFFON, TOFFOF)

Function

Use the system variable $AA_TOFF[<n>] to overlay the effective tool lengths in accordance with the three tool directions three-dimensionally in real time.

The three geometry axis identifiers are used as index <n>. Thus, the number of active direction offsets is determined by the geometry axes that are active at the same time.

All offsets can be active at the same time.

The online tool length compensation function can be used for:

- Orientation transformation TRAORI
- Orientable toolholder TCARR

Note

Online tool length compensation is an **option,** which must be enabled in advance. This function is only practical in conjunction with an active orientation transformation or an active orientable toolholder.

Syntax

```
TRAORI
TOFFON(<compensation direction>[,<offset value>])
WHEN TRUE DO $AA_TOFF[<compensation direction>]        ; In synchronized actions.
...
TOFFOF(<compensation direction>)
```

For more information about programming online tool length compensation in motion-synchronous actions, see "Synchronized actions (Page 553)".

Meaning

`TOFFON`: **Activate** online tool length compensation

- `<compensation direction>`: Tool direction (`X`, `Y`, `Z`), in which the online tool length compensation should be active.
- `<offset value>`: When activating, an offset value can be specified for the relevant direction of compensation and this is immediately recovered.

`TOFFOF`: **Reset** online tool length compensation

The compensation values in the specified compensation direction are reset and a pre-processing stop is initiated.

Examples

Example 1: Selecting the tool length compensation

Program code	Comment
MD21190 $MC_TOFF_MODE = 1	; Absolute values are approached.
MD21194 $MC_TOFF_VELO[0] =1000	
MD21196 $MC_TOFF_VELO[1] =1000	
MD21194 $MC_TOFF_VELO[2] =1000	
MD21196 $MC_TOFF_ACCEL[0] =1	
MD21196 $MC_TOFF_ACCEL[1] =1	
MD21196 $MC_TOFF_ACCEL[2] =1	
N5 DEF REAL XOFFSET	
N10 TRAORI(1)	; Transformation on.
N20 TOFFON(Z)	; Activation of online tool length compensation for the Z tool direction.
N30 WHEN TRUE DO $AA_TOFF[Z]=10 G4 F5	; A TLC of 10 is interpolated for the Z tool direction.
...	
N100 XOFFSET=$AA_TOFF_VAL[X]	; Assigns actual compensation in the X direction.
N120 TOFFON(X,-XOFFSET) G4 F5	; For the X tool direction, the TLC is reduced back to 0.

Example 2: Deselect the tool length compensation

Program code	Comment
N10 TRAORI(1)	; Transformation on.
N20 TOFFON(X)	; Activation of online tool length compensation for the X tool direction.
N30 WHEN TRUE DO $AA_TOFF[X]=10 G4 F5	; A TLC of 10 is interpolated for the X tool direction.
...	
N80 TOFFOF(X)	; Position offset of the X tool direction is deleted: ...$AA_TOFF[X]=0 No axis is moved. The position offset is added to the actual position in the Work corresponding to the actual orientation.

Further information

Block preparation

During block preparation in preprocessing, the current tool length offset active in the main run is also taken into consideration. To allow extensive use to be made of the maximum permissible axis velocity, it is necessary to stop block preparation with a `STOPRE` preprocessing stop while a tool offset is established.

The tool offset is always known at the time of run-in when the tool length offsets are not changed after program start or if more blocks have been processed after changing the tool length offsets than the IPO buffer can accommodate between run-in and main run.

Variable $AA_TOFF_PREP_DIFF

The dimension for the difference between the currently active compensation in the interpolator and the compensation that was active at the time of block preparation can be polled in the variable $AA_TOFF_PREP_DIFF[<n>].

Adjusting machine data and setting data

The following system data is available for online tool length offset:

- MD20610 $MC_ADD_MOVE_ACCEL_RESERVE (acceleration margin for overlaid motion)
- MD21190 $MC_TOFF_MODE

  Content of system variable$AA_TOFF[<n>] is moved through as absolute value or is integrated up.
- MD21194 $MC_TOFF_VELO (velocity of the online tool length compensation)
- MD21196 $MC_TOFF_ACCEL (acceleration of the online tool length compensation)
- Setting data for presetting limit values :
  SD42970 $SC_TOFF_LIMIT (upper limit of the tool length compensation value)

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

9.11 Cutting data modification for tools that can be rotated (CUTMOD)

Function

Using the function "cutting data modification for rotatable tools", the changed geometrical relationships, that are obtained relative to the workpiece being machined when rotating tools (predominantly turning tools, but also drilling and milling tools) can be taken into account with the tool compensation.

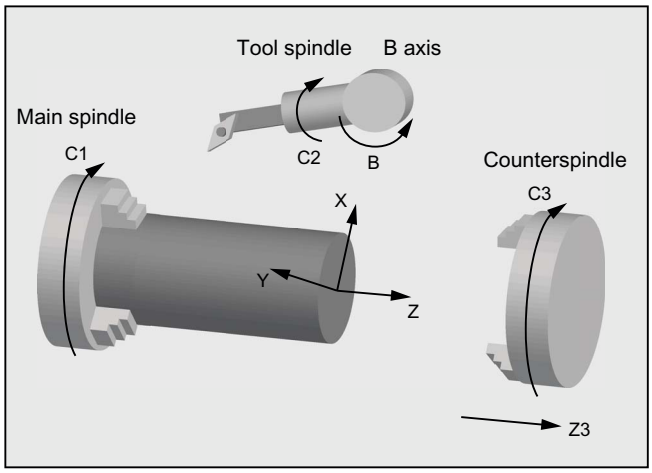


Figure 9-1 Rotatable tool for a lathe

The actual tool rotation is always determined from a currently active toolholder that can be orientated (refer to "Tool length compensation for toolholders that can be orientated (Page 433)").

The function is activated using the command `_movePathCircular()`.

Syntax

```
CUTMOD=<value>
```

Meaning

`CUTMOD` Command to switch-in the function "cutting data modification for tools that can be rotated"

`<value>` The following values can be assigned to the `CUTMOD` command:

0 The function is deactivated.

The values supplied from system variables $P_AD... are the same as the corresponding tool parameters.

> 0 The function is activated if a toolholder that can be orientated with the specified number is active, i.e. the activation is linked to a specific toolholder that can be orientated.

The values supplied from system variables $P_AD... may be modified with respect to the corresponding tool parameters depending on the active rotation.

The deactivation of the designated toolholder that can be orientated temporarily deactivates the function; the activation of another toolholder that can be orientated permanently deactivates it. This is the reason that in the first case, the function is re-activated when again selecting the same toolholder that can be orientated; in the second case, a new selection is required - even if at a subsequent time, the toolholder that can be orientated is re-activated with the specified number.

The function is not influenced by a reset.

-1 The function is always activated if a toolholder that can be orientated is active.

When changing the toolholder or when de-selecting it and a subsequent new selection, `CUTMOD` does not have to be set again.

-2 The function is always activated if a toolholder that can be orientated is active whose number is the same as the currently active toolholder that can be orientated.

If a toolholder that can be orientated is not active, then this has the same significance as `CUTMOD=0`. If a toolholder that can be orientated is active, then this has the same significance as when directly specifying the actual toolholder number.

< -2 Values less than -2 are ignored, i.e. this case is treated as if `CUTMOD` was not programmed.

Note:
This value range should not be used as it is reserved for possible subsequent expansions.

Note

SD42984 $SC_CUTDIRMOD

The function can be activated using the `CUTMOD` command replaces the function that can be activated using the setting data SD42984 $SC_CUTDIRMOD. However, this function remains available unchanged. However, as it doesn't make sense to use both functions in parallel, it can only be activated if `CUTMOD` is equal to zero.

Example

The following example refers to a tool with tool nose position 3 and a toolholder that can be orientated, which can rotate the tool around the B axis.

The numerical values in the comments specify the end of block positions in the machine coordinates (MCS) in the sequence X, Y, Z.

```
Program code                                                Comment
N10 $TC_DP1[1,1]=500
N20 $TC_DP2[1,1]=3                                          ; Tool nose position
N30 $TC_DP3[1,1]=12
N40 $TC_DP4[1,1]=1
N50 $TC_DP6[1,1]=6
N60 $TC_DP10[1,1]=110                                       ; Holder angle
N70 $TC_DP11[1,1]=3                                         ; Cut direction
N80 $TC_DP24[1,1]=25                                        ; Clearance angle

N90 $TC_CARR7[2]=0 $TC_CARR8[2]=1 $TC_CARR9[2]=0            ; B axis
N100 $TC_CARR10[2]=0 $TC_CARR11[2]=0 $TC_CARR12[2]=1        ; C axis
N110 $TC_CARR13[2]=0
N120 $TC_CARR14[2]=0
N130 $TC_CARR21[2]=X
N140 $TC_CARR22[2]=X
N150 $TC_CARR23[2]="M"

N160 TCOABS CUTMOD=0
N170 G18 T1 D1 TCARR=2                                        X          Y          Z
N180 X0 Y0 Z0 F10000                                        ; 12.000     0.000      1.000

N190 $TC_CARR13[2]=30
N200 TCARR=2
N210 X0 Y0 Z0                                               ; 10.892     0.000      -5.134
N220 G42 Z-10                                               ; 8.696      0.000      -17.330
N230 Z-20                                                   ; 8.696      0.000      -21.330
N240 X10                                                    ; 12.696     0.000      -21.330
N250 G40 X20 Z0                                             ; 30.892     0.000      -5.134

N260 CUTMOD=2 X0 Y0 Z0                                      ; 8.696      0.000      -7.330
N270 G42 Z-10                                               ; 8.696      0.000      -17.330
N280 Z-20                                                   ; 8.696      0.000      -21.330
N290 X10                                                    ; 12.696     0.000      -21.330
N300 G40 X20 Z0                                             ; 28.696     0.000      -7.330

N310 M30
```

Explanations:

In block N180, initially the tool is selected for CUTMOD=0 and non-rotated toolholders that can be orientated. As all offset vectors of the toolholder that can be orientated are 0, the position that corresponds to the tool lengths specified in $TC_DP3[1,1] and $TC_DP4[1,1] is approached.

The toolholder that can be orientated with a rotation of 30° around the B axis is activated in block N200. As the tool nose position is not modified due to CUTMOD=0, the old tool nose reference point is decisive just as before. This is the reason that in block N210 the position is approached, which keeps the old tool nose reference point at the zero (i.e. the vector (1, 12) is rotated through 30° in the Z/X plane).

In block N260, contrary to block N200 CUTMOD=2 is effective. As a result of the rotation of the toolholder that can be orientated, the modified tool nose position becomes 8. The consequence of this is also the different axis positions.

The tool radius compensation (TRC) is activated in blocks N220 and/or N270. The different tool nose positions in both program sections have no effect on the end positions of the blocks in which the TRC is active; the corresponding positions are therefore identical. The different tool nose positions only become effective again in the deselect blocks N260 and/or N300.

Further information

Effectiveness of the modified cutting data

The modified tool nose position and the modified tool nose reference point are immediately effective when programming, even for a tool that is already active. A tool does not have to be re-selected for this purpose.

Influence of the active machining plane

To determine modified tool nose position, cutting direction and holder or clearance angle, the evaluation of the cutting edge in the active plane (G17 - G19) is decisive.

However, if setting data SD42940 $SC_TOOL_LENGTH_CONST (change of the tool length component when selecting the plane), a valid value not equal to zero (plus or minus 17, 18 or 19), then its contents define the plane in which the relevant quantities are evaluated.

System variables

The following system variables are available:

System variables	Meaning
$P_CUTMOD_ANG / $AC_CUTMOD_ANG	Supplies the (non-rounded) angle in the active machining plane, that was used as basis for the modification of the cutting data (tool nose position, cut direction, clearance angle and holder angle) for the functions activated using CUTMOD and/or $SC_CUTDIRMOD. $P_CUTMOD_ANG refers to the actual state in the preprocessing, $AC_CUTMOD_ANG to the actual main run block.

System variables	Meaning
$P_CUTMOD / $AC_CUTMOD	Reads the currently valid value that was last programmed using the command CUTMOD (number of the toolholder that should be activated for the cutting data modification). If the last programmed CUTMOD value = -2 (activation with the currently active toolholder that can be orientated), then the value -2 is not returned in $P_CUTMOD, but the number of the active toolholder that can be orientated at the time of programming. $P_CUTMOD refers to the actual state in the preprocessing, $AC_CUTMOD to the actual main run block.
$P_CUT_INV / $AC_CUT_INV	Supplies the value TRUE if the tool is rotated so that the spindle direction of rotation must be inverted. To do this, the following four conditions must be fulfilled in the block to which the read operations refer: 1. If a turning or grinding tool is active (tool types 400 to 599 and / or SD42950 $SC_TOOL_LENGTH_TYPE = 2). 2. The cutting influence was activated using the language command CUTMOD. 3. A toolholder that can be orientated is active, which was designated using the numerical value of CUTMOD. 4. The toolholder that can be orientated rotates the tool around an axis in the machining plane (this is typically the C axis) so that the resulting perpendicular of the tool cutting edge is rotated with respect to the initial position by more than 90° (typically 180°). The contents of the variable are FALSE if at least one of the specified four conditions is not fulfilled. For tools whose tool nose position is not defined, the value of the variable is always FALSE. $P_CUT_INV refers to the actual state in the preprocessing and $AC_CUT_INV to the actual main run block.

All main run variables ($AC_CUTMOD_ANG, $AC_CUTMOD and $AC_CUT_INV) can be read in synchronized actions. A read access operation from the preprocessing generates a preprocessing stop.

Modified cutting data:

If a tool rotation is active, the modified data is made available in the following system variables:

System variable	Meaning
$P_AD[2]	Cutting edge position
$P_AD[10]	Holder angle
$P_AD[11]	Cut direction
$P_AD[24]	Clearance angle

Note

The data is always modified with respect to the corresponding tool parameters ($TC_DP2[..., ...] etc.) if the function "cutting data modification for rotatable tools" was activated using the command `CUTMOD` and a toolholder that can be orientated, which causes a rotation, is activated.

References

For additional information on the function "cutting data modification for rotatable tools", refer to:

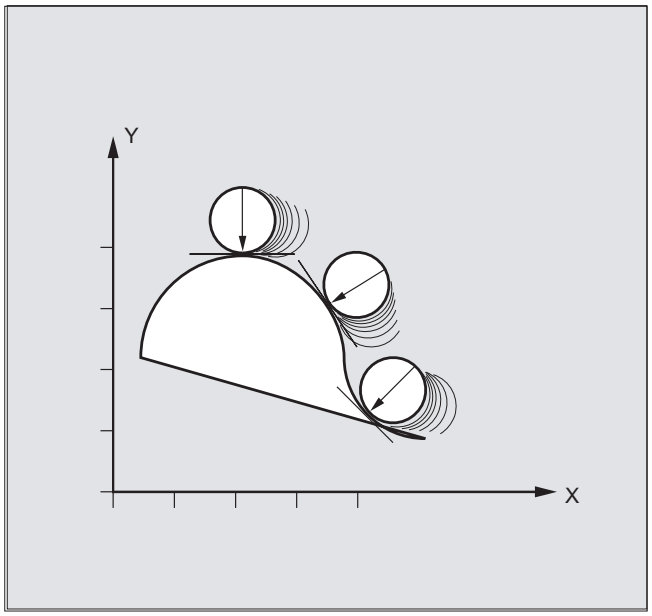
Function Manual Basic Functions; Tool Offset (W1)

Path traversing behavior 10

10.1 Tangential control (TANG, TANGON, TANGOF, TLIFT, TANGDEL)

Function

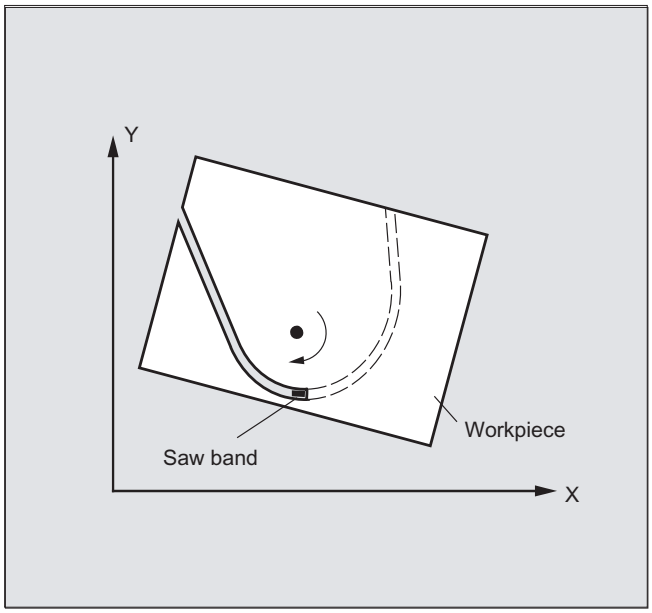
The following axis follows the path of the leading axis along the tangent. This allows alignment of the tool parallel to the contour. Using the angle programmed in the TANGON instruction, the tool can be positioned relative to the tangent.



Application

Tangential control can, for example, be used in the applications:

- Tangential positioning of a rotatable tool during nibbling
- Tracking the workpiece alignment for a bandsaw (see the following diagram).
- Positioning of a dressing tool on a grinding wheel
- Positioning of a cutting wheel for glass or paper working
- Tangential feed of a wire for 5-axis welding.



Syntax

Defining tangential tracking:
```
TANG(<following axis>,<leading axis 1>,<leading axis 2>,<coupling
factor>,<KS>,<Opt>)
```

Activating tangential control:
```
TANGON(<following axis>,<angle>,<Dist>,<angular tolerance>)
```

Deactivating tangential control:
```
TANGOF(<following axis>)
```

Activating the "Insert intermediate block at contour corners" function:
```
TLIFT(<following axis>)
```

The `TLIFT` operation is specified after the axis assignment with `TANG(...)`.

Deactivating the "Inserting intermediate block at contour corners" function:

Repeat the `TANG(...)` operation without a following `TLIFT(<following axis>)`.

Deleting definition of tangential tracking:
```
TANGDEL(<following axis>)
```

An existing user-defined tangential tracking must be deleted if a new tangential tracking with the same following axis is defined in the preparation call `TANG`. Deletion is only possible if the coupling with `TANGOF(<following axis>)` is deactivated.

Meaning

TANG:	Preparatory operation for the definition of tangential tracking:
TANGON:	Activate tangential control for the specified following axis
TANGOF:	Deactivate tangential control for the specified following axis
TLIFT:	Activate the "Insert intermediate block at contour corners" function
TANGDEL:	Delete definition of tangential tracking
<following axis>:	Following axis: additional tangential following rotary axis.
<leading axis 1>,<leading axis 2>:	Leading axes: path axes, which determine the tangent for the following axis.
<coupling factor>:	Coupling factor: Relationship between the angular change of the tangent and the tracked axis Default: 1 **Note:** A coupling factor of 1 does not have to be programmed explicitly.
<CS>:	Identification letter for coordinate system "B": Basis coordinate system (Default) **Note:** <CS> = "B" does not have to be explicitly programmed. "W": Workpiece coordinate system (not available)
<Opt>:	Optimization "S": Standard (default) **Note:** <Opt> = "S" does not have to be explicitly programmed. "P": Automatic adaptation of the characteristic over time of the tangential axis and the contour **Note:** With <Opt> = "P", the dynamic properties of the following axis are taken into account in the velocity limitation of the leading axes. This setting is especially recommended when using kinematic transformations.
<angle>:	Offset angle of following axis
<Dist>:	Smoothing path of following axis (required for <Opt> = "P")
<angular tolerance>:	Angular tolerance of the following axis (optional; only evaluated for <Opt> = "P") **Note:** Parameters <Dist> and <Angular tolerance> specifically limit the error between the tracked axis and the tangent of the leading axes.

Examples

Example 1: Defining and activating tangential tracking

```
Program code                          Comment
N10 TANG(C,X,Y,1,"B","P")             ; Definition of a tangential tracking: Rotary
                                        axis C should follow geometry axes X and Y.
N20 TANGON(C,90)                      ; The C axis is a following axis. On every
                                        movement of the path axes, it is rotated into a
                                        position at 90° to the path tangent.
...
```

Note

Simplified programming

`TANG(C,X,Y,1,"B","P")` can be more simply programmed as `TANG(C,X,Y,,,"P")`.

Example 2: Plane change

```
Program code                Comment
N10 TANG(A,X,Y,1)           ; 1st definition of tangential tracking.
N20 TANGON(A)               ; Activating the coupling.
N30 X10 Y20                 ; Radius
...
N80 TANGOF(A)               ; Deactivate the 1st coupling.
N90 TANGDEL(A)              ; Delete the 1st definition.
...
TANG(A,X,Z)                 ; 2nd definition of tangential tracking.
TANGON(A)                   ; Activate the new coupling.
...
N200 M30
```

Example 3: Geometry axis changeover and TANGDEL

No alarm is produced.

```
Program code                Comment
N10 GEOAX(2,Y1)             ; Y1 is geometry axis 2.
N20 TANG(A,X,Y)             ; 1st definition of tangential tracking.
N30 TANGON(A,90)            ; Activate tracking with Y1.
N40 G2 F8000 X0 Y0 I0 J50
N50 TANGOF(A)               ; Deactivate tracking with Y1.
N60 TANGDEL(A)              ; Delete the 1st definition.
```

```
Program code                    Comment
N70 GEOAX(2, Y2)                ; Y2 is the new geometry axis 2
N80 TANG(A,X,Y)                 ; 2nd definition of tangential tracking.
N90 TANGON(A,90)                ; Activate tracking with Y2.
...
```

Example 4: Tangential tracking with automatic optimization

Y1 is geometry axis 2.

```
Program code                                        Comment
...
N80 G0 C0
N100 F=50000
N110 G1 X1000 Y500
N120 TRAORI
N130 G642                                           ; Smoothing and maintaining the
                                                      maximum permitted path
                                                      deviation:
N171 TRANS X50 Y50
N180 TANG(C,X,Y,1,,"P")                             ; Definition, tangential
                                                      tracking with automatic
                                                      optimization of the path
                                                      velocity.
N190 TANGON(C,0,5.0,2.0)                            ; Activating tangential tracking
                                                      with automatic optimization:
                                                      Smoothing distance, 5 mm
                                                      angular tolerance, 2 degrees.
N210 G1 X1310 Y500
N215 G1 X1420 Y500
N220 G3 X1500 Y580 I=AC(1420) J=AC(580)
N230 G1 X1500 Y760
N240 G3 X1360 Y900 I=AC(1360) J=AC(760)
N250 G1 X1000 Y900
N280 TANGOF(C)
N290 TRAFOOF
N300 M02
```

Further information

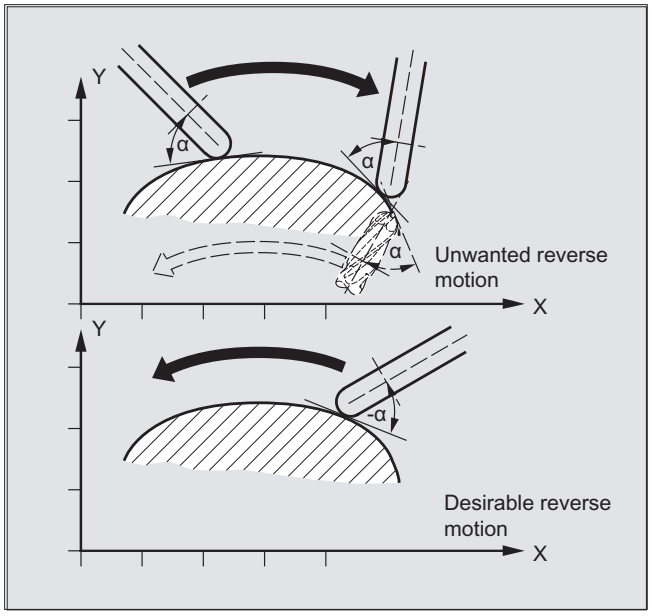
Defining following axis and leading axis

TANG is used to define the following and leading axes.

A coupling factor specifies the relationship between an angle change on the tangent and the following axis. Its value is generally 1 (default).

Limit angle using the working area limitation

For path movements, which oscillate back and forth, the tangent jumps through 180° at the turning point on the path and the orientation of the following axis changes accordingly. This behavior is generally inappropriate: The return movement should be traversed at the same negative offset angle as the approach movement:



To do this, limit the working area of the following axis (G25, G26). The working area limit must be active at the instant of path reversal (WALIMON). If the offset angle lies outside the working area limit, an attempt is made to return to the permissible working area with the negative offset angle.

Insert intermediate block at contour corners (TLIFT)

At one corner of the contour the tangent changes and thus the setpoint position of the following axis. The axis normally tries to compensate this step change at its maximum possible velocity. However, this causes a deviation from the desired tangential position over a certain distance on the contour after the corner. If such a deviation is unacceptable for technological reasons, the instruction TLIFT can be used to force the controller to stop at the corner and to rotate the following axis to the new tangent direction in an automatically generated intermediate block.

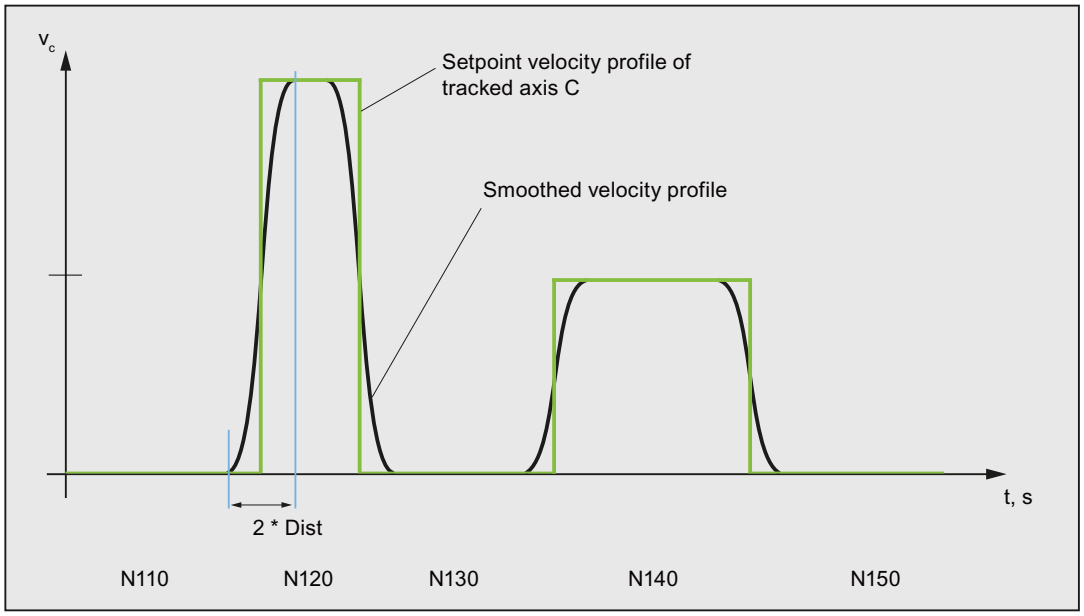
The path axis is used for turning if the following axis has been used once as the path axis. A maximum axis velocity of the following axis can be achieved with function
TFGREF[<axis>]=0.001.

If the follow-up axis was not previously traversed as a path axis it is now traversed as a positioning axis. The velocity is then dependent on the positioning velocity in the machine data.

The axis is rotated at its maximum possible velocity.

Optimization option

If the automatic optimization is selected (<Opt> = "P") and if the parameter smoothing distance (<Dist>) and angular tolerance (<angular tolerance>) are specified for the following axis, then for tangential tracking, velocity steps of the slave axis as a result of steps in the leading axis contour are smoothed. In this case, the following axis is controlled with look ahead (refer to the diagram) in order to keep the deviation as small as possible.



Defining the angle change

The angular change limit at which an intermediate block is automatically inserted is defined using the following machine data:

MD37400 $MA_EPS_TLIFT_TANG_STEP (Tangent angle for corner recognition)

Effect on transformations

The position of the rotary axis to which follow-up control is applied can act as the input value for a transformation.

Explicit positioning of the following axis

If an axis, which is following your lead axes, is positioned explicitly the position is added to the programmed offset angle.

All distance data is permissible (path and positioning axis motion).

Status of coupling

The status of the coupling can be interrogated in the NC part program using the system variable $AA_COUP_ACT[<axis>]:

Value	Meaning
0	No coupling active
1,2,3	Tangential follow-up active

10.2 Feedrate characteristic (FNORM, FLIN, FCUB, FPO)

Function

To permit flexible definition of the feed characteristic, the feed programming according to DIN 66025 has been extended by linear and cubic characteristics.

The cubic characteristics can be programmed either directly or as interpolating splines. These additional characteristics make it possible to program continuously smooth velocity characteristics depending on the curvature of the workpiece to be machined.

These additional characteristics make it possible to program continuously smooth velocity characteristics depending on the curvature of the workpiece to be machined.

Syntax

```
F… FNORM
F… FLIN
F… FCUB
F=FPO(…,…,…)
```

Meaning

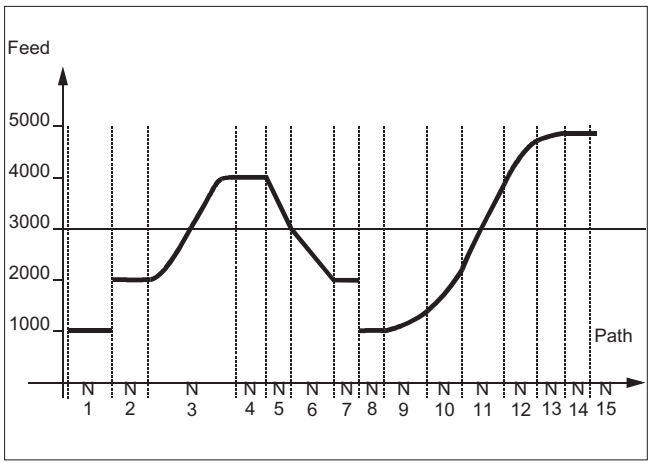
`FNORM`	Basic setting. The feed value is specified as a function of the traverse path of the block and is then valid as a modal value.
`FLIN`	Path velocity profile **linear:** The feed value is approached linearly via the traverse path from the current value at the block beginning to the block end and is then valid as a modal value. The response can be combined with G93 and G94.
`FCUB`	Path velocity profile **cubic:** The blockwise programmed F values (relative to the end of the block) are connected by a spline. The spline begins and ends tangentially with the previous and following defined feedrate and takes effect with G93 and G94. If the F address is missing from a block, the last F value to be programmed is used.
`F=FPO…`	**Polynomial** path velocity profile: The F address defines the feed characteristic via a polynomial from the current value to the block end. The end value is valid thereafter as a modal value.

Feed optimization on curved path sections

Feed polynomial `F=FPO` and feed spline `FCUB` should always be traversed at constant cutting rate `CFC`, thereby allowing a jerk-free setpoint feed profile to be generated. This enables creation of a continuous acceleration setpoint feed profile.

Example: Various feed profiles

This example shows you the programming and graphic representation of various feed profiles.

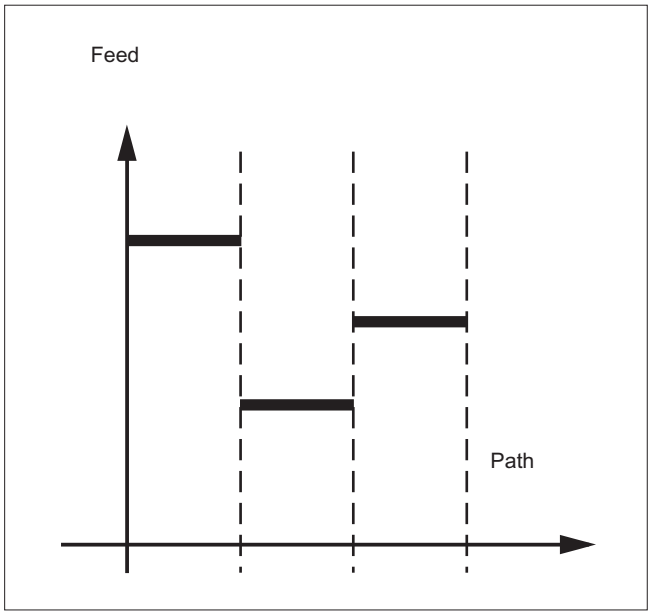


Program code	Comment
N1 F1000 FNORM G1 X8 G91 G64	; Constant feedrate profile, incremental dimension data
N2 F2000 X7	; Setpoint velocity step change
N3 F=FPO(4000, 6000, -4000)	; Feed profile via polynomial with feed 4000 at the end of the block
N4 X6	; Polynomial feedrate 4000 is valid as modal value
N5 F3000 FLIN X5	; Linear feedrate profile
N6 F2000 X8	; Linear feedrate profile
N7 X5	Linear feedrate is valid as modal value
N8 F1000 FNORM X5	; Constant feedrate profile with acceleration step change
N9 F1400 FCUB X8	; All of the following F values programmed in blocks are connected with splines
N10 F2200 X6	
N11 F3900 X7	
N12 F4600 X7	
N13 F4900 X5	; Switch-out spline profile
N14 FNORM X5	
N15 X20	

FNORM

The feed address F defines the path feedrate as a constant value according to DIN 66025.

Please refer to Programming Manual "Fundamentals" for more detailed information on this subject.

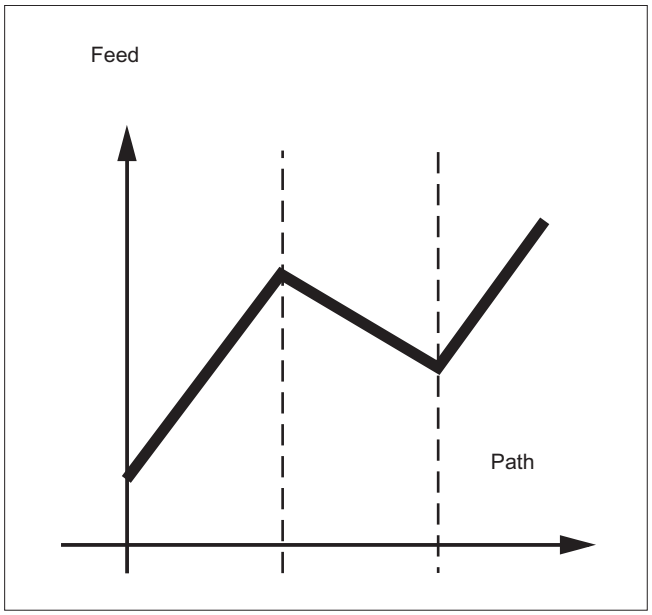


FLIN

The feedrate characteristic is approached linearly from the current feedrate value to the programmed F value until the end of the block.

Example:

```
N30 F1400 FLIN X50
```

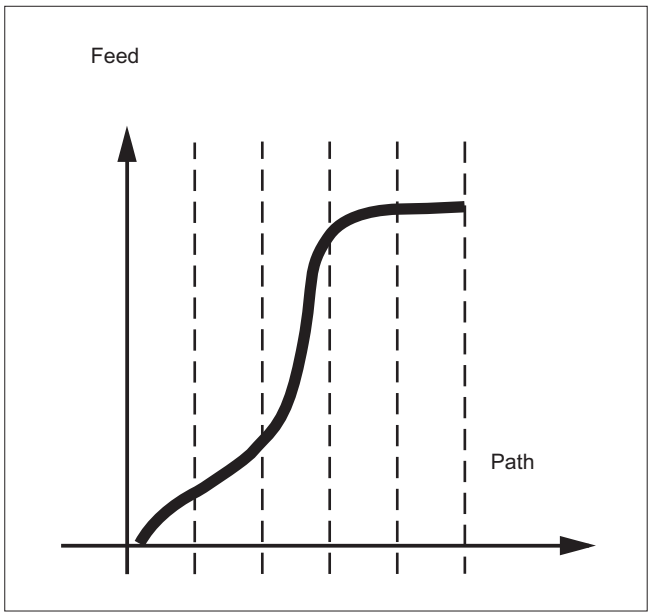


FCUB

The feedrate is approached according to a cubic characteristic from the current feedrate value to the programmed F value until the end of the block. The controller uses splines to connect all the feedrate values programmed non-modally that have an active FCUB. The feedrate values act here as interpolation points for calculation of the spline interpolation.

Example:

```
N50 F1400 FCUB X50

N60 F2000 X47

N70 F3800 X52
```



F=FPO(…,…,…)

The feedrate characteristic is programmed directly via a polynomial. The polynomial coefficients are specified according to the same method used for polynomial interpolation.

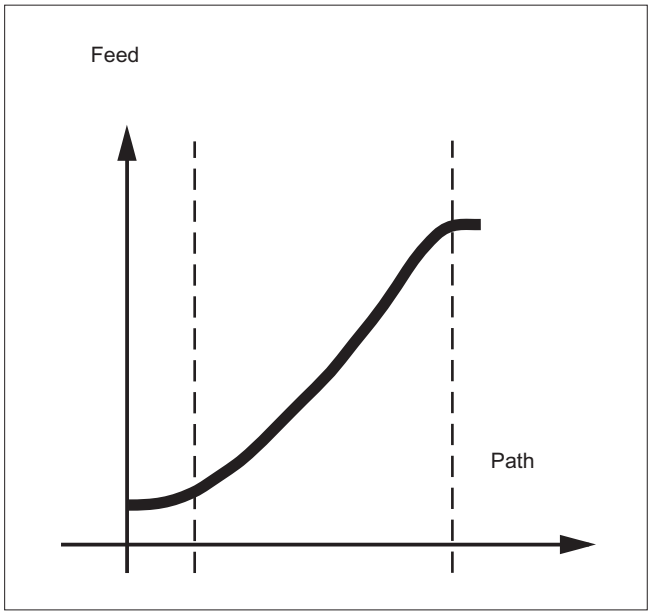
Example:

```
F=FPO(endfeed, quadf, cubf)
```

endfeed, quadf and cubf are previously defined variables.

endfeed:	Feedrate at block end
quadf:	Quadratic polynomial coefficient
cubf:	Cubic polynomial coefficient

With an active `FCUB`, the spline is linked tangentially to the characteristic defined via `FPO` at the block beginning and block end.



Supplementary conditions

The functions for programming the path traversing characteristics apply regardless of the programmed feedrate characteristic.

The programmed feedrate characteristic is always absolute regardless of G90 or G91.

Feedrate characteristic FLIN and FCUB are active with

G93 and G94.

FLIN and FCUB **is not active with**

G95, G96/G961 and G97/G971.

Active compressor COMPON

With an active compressor COMPON the following applies when several blocks are joined to form a spline segment:

FNORM:

The F word of the last block in the group applies to the spline segment.

FLIN:

The F word of the last block in the group applies to the spline segment.
The programmed F value applies until the end of the segment and is then approached linearly.

FCUB:

The generated feedrate spline deviates from the programmed end points by an amount not exceeding the value set in machine data MD20172 $MC_COMPRESS_VELO_TOL.

F=FPO(...,...,...)

These blocks are not compressed.

10.3 Acceleration behavior

10.3.1 Acceleration mode (BRISK, BRISKA, SOFT, SOFTA, DRIVE, DRIVEA)

Function

The following part program commands are available for programming the current acceleration mode:

- `BRISK`, `BRISKA`

  The single axes or the path axes traverse with maximum acceleration until the programmed feedrate is reached (**acceleration without jerk limitation**).

- `SOFT`, `SOFTA`

  The single axes or the path axes traverse with constant acceleration until the programmed feedrate is reached (**acceleration with jerk limitation**).

- `DRIVE`, `DRIVEA`

  The single axes or the path axes traverse with maximum acceleration up to a programmed velocity limit (MD setting!). The acceleration rate is then reduced (MD setting) until the programmed feedrate is reached.

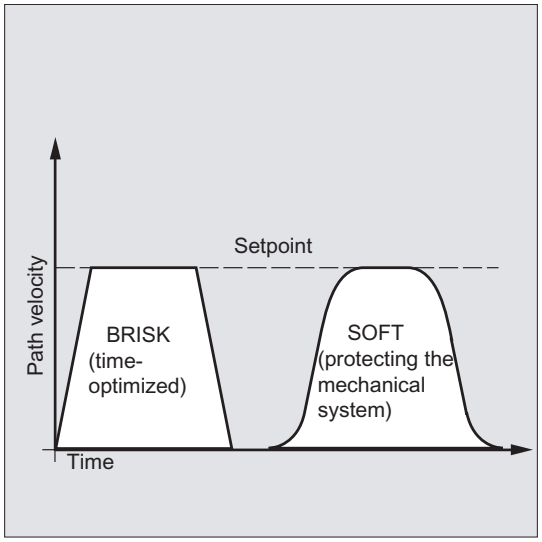


Figure 10-1 Path velocity curve with `BRISK` and `SOFT`

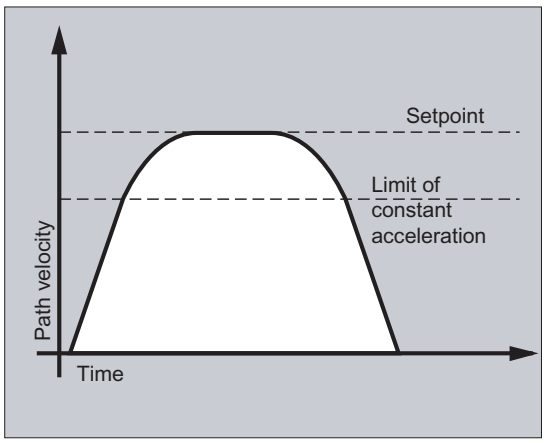


Figure 10-2 Path velocity curve with DRIVE

Syntax

```
BRISK
BRISKA(<axis1>,<axis2>,…)
SOFT
SOFTA(<axis1>,<axis2>,…)
DRIVE
DRIVEA(<axis1>,<axis2>,…)
```

Meaning

BRISK:	Command for activating the "acceleration without jerk limitation" for the path axes.
BRISKA:	Command for activating the "acceleration without jerk limitation" for single axis movements (JOG, JOG/INC, positioning axis, oscillating axis, etc.).
SOFT:	Command for activating the "acceleration with jerk limitation" for the path axes.
SOFTA:	Command for activating the "acceleration with jerk limitation" for single axis movements (JOG, JOG/INC, positioning axis, oscillating axis, etc.).
DRIVE:	Command for activating the reduced acceleration above a configured velocity limit (MD35220 $MA_ACCEL_REDUCTION_SPEED_POINT) for the path axes.
DRIVEA:	Command for activating the reduced acceleration above a configured velocity limit (MD35220 $MA_ACCEL_REDUCTION_SPEED_POINT) for single axis movements (JOG, JOG/INC, positioning axis, oscillating axis, etc.).
(<axis1>,<axis2>, etc.):	Single axes for which the called acceleration mode is to apply.

Supplementary conditions

Changing acceleration mode during machining

If the acceleration mode is changed in a part program during machining (BRISK ↔ SOFT), then there is a block change with exact stop at the end of the block during the transition even with continuous-path mode.

Examples

Example 1: SOFT and BRISKA

```
Program code
N10 G1 X… Y… F900 SOFT
N20 BRISKA(AX5,AX6)
...
```

Example 2: DRIVE and DRIVEA

```
Program code
N05 DRIVE
N10 G1 X… Y… F1000
N20 DRIVEA (AX4, AX6)
...
```

References

Function Manual, Basic Functions; Acceleration (B2)

10.3.2 Influence of acceleration on following axes (VELOLIMA, ACCLIMA, JERKLIMA)

Function

In the case of axis couplings (tangential correction, coupled motion, master value coupling, electronic gear; see "Axis couplings (Page 495)").

The dynamics limits of the following axes/spindles can be manipulated using the VELOLIMA, ACCLIMA, and JERKLIMA functions from the part program or from synchronized actions, even if the axis coupling is already active.

Note

The JERKLIMA function is not available for all types of coupling.

References:

- Function Manual, Special Functions; Axis Couplings (M3)
- Function Manual, Extended Functions; Synchronous Spindle (S3)

Note

Availability for SINUMERIK 828D

The VELOLIMA, ACCLIMA and JERKLIMA functions can only be used with SINUMERIK 828D in conjunction with the "coupled motion" function!

Syntax

```
VELOLIMA(<axis>)=<value>
ACCLIMA(<axis>)=<value>
JERKLIMA(<axis>)=<value>
```

Meaning

VELOLIMA:	Command to correct the parameterized maximum **velocity**
ACCLIMA:	Command to correct the parameterized maximum **acceleration**
JERKLIMA:	Command to correct the parameterized maximum **jerk**
<axis>:	Following axis whose dynamics limits need to be corrected
<value>:	Percentage correction value

Examples

Example 1: Correction of the dynamics limits for a following axis (AX4)

```
Program code                Comment
...
VELOLIMA[AX4]=75            ; Limits correction to 75% of the maximum axial velocity
                              stored in the machine data
ACCLIMA[AX4]=50             ; Limits correction to 50% of the maximum axial
                              acceleration stored in the machine data
JERKLIMA[AX4]=50            ; Limits correction to 50% of the maximum axial jerk
                              stored in the machine data
...
```

Example 2: Electronic gear

Axis 4 is coupled to axis X via an "electronic gear" coupling. The acceleration capacity of the following axis is limited to 70% of the maximum acceleration. The maximum permissible velocity is limited to 50% of the maximum velocity. Once the coupling has been activated successfully, the maximum permissible velocity is restored to 100%.

```
Program code                                Comment
...
N120 ACCLIMA[AX4]=70                        ; Reduced maximum acceleration
N130 VELOLIMA[AX4]=50                       ; Reduced maximum velocity
...
N150 EGON(AX4,"FINE",X,1,2)                 ; Activation of the EG coupling
...
N200 VELOLIMA[AX4]=100                      ; Full maximum velocity
...
```

Example 3: Influencing master value coupling by static synchronized action

Axis 4 is coupled to X by master value coupling. The acceleration response is limited to position 80% by static synchronized action 2 from position 100.

```
Program code                                                                Comment
...
N120 IDS=2 WHENEVER $AA_IM[AX4] > 100 DO ACCLIMA[AX4]=80                    ; Synchronized action
N130 LEADON(AX4, X, 2)                                                      ; Master value coupling on
...
```

10.3.3 Activation of technology-specific dynamic values (DYNNORM, DYNPOS, DYNROUGH, DYNSEMIFIN, DYNFINISH)

Function

Using the "Technology" G group, the appropriate dynamic response can be activated for five varying technological machining steps.

Dynamic values and G commands can be configured and are, therefore, dependent on machine data settings (→ machine manufacturer).

References:
Function Manual, Basic Functions; Continuous-Path Mode, Exact Stop, Look Ahead (B1)

Syntax

Activate dynamic values:

```
DYNNORM
DYNPOS
DYNROUGH
DYNSEMIFIN
DYNFINISH
```

Note

The dynamic values are already active in the block in which the associated G command is programmed. Machining is not stopped.

Read or write a specific field element:

```
R<m>=$MA...[n,X]
$MA...[n,X]=<value>
```

Meaning

DYNNORM:	G command for activating **normal dynamic response**
DYNPOS:	G command for activating the dynamic response for **positioning mode**, **tapping**
DYNROUGH:	G command for activating the dynamic response for **roughing**
DYNSEMIFIN:	G command for activating the dynamic response for **finishing**
DYNFINISH:	G command for activating the dynamic response for **smooth-finishing**
R<m>:	R-parameter with number <m>
$MA...[n,X]:	Machine data with field element affecting dynamic response
<n>:	Array index Range of values: 0 ... 4 0 Normal dynamic response (DYNNORM) 1 Dynamic response for positioning mode (DYNPOS) 2 Dynamic response for roughing (DYNROUGH) 3 Dynamic response for finishing (DYNSEMIFIN) 4 Dynamic response for smooth-finishing (DYNFINISH)
<X> :	Axis address
<value>:	Dynamic value

Examples

Example 1: Activate dynamic values

Program code	Comment
DYNNORM G1 X10	; Basic position
DYNPOS G1 X10 Y20 Z30 F…	; Positioning mode, tapping
DYNROUGH G1 X10 Y20 Z30 F10000	; Roughing
DYNSEMIFIN G1 X10 Y20 Z30 F2000	; Finishing
DYNFINISH G1 X10 Y20 Z30 F1000	; Smooth finishing

Example 2: Read or write a specific field element

Maximum acceleration for roughing, axis X

Program code	Comment
R1=$MA_MAX_AX_ACCEL[2,X]	; Read
$MA_MAX_AX_ACCEL[2,X]=5	; Write

10.4 Traversing with feedforward control (FFWON, FFWOF)

Function

The feedforward control reduces the velocity-dependent overtravel when contouring towards zero. Traversing with feedforward control permits higher path accuracy and thus improved machining results.

Syntax

```
FFWON
FFWOF
```

Meaning

FFWON: Command to **activate** the feedforward control
FFWOF: Command to **deactivate** the feedforward control

Note

The type of feedforward control and which path axes are to be traversed with feedforward control is specified via machine data.

Default: Velocity-dependent feedforward control

Option: Acceleration-dependent feedforward control

Example

```
Program code
N10 FFWON
N20 G1 X… Y… F900 SOFT
```

10.5 Programmable contour accuracy (CPRECON, CPRECOF)

Function

The "Programmable contour accuracy" function reduces the path error on curved contours through automatic adaptation of the velocity.

The contour accuracy to be maintained is specified depending on the configuration of the machine (MD20470 $MC_MC_CPREC_WITH_FFW; see machine manufacturer specifications) either via the setting data $SC_CONTPREC or via the programmed contour tolerance CTOL. The smaller the value and the smaller the K_V factor of the geometry axes, the greater the path feedrate is reduced on curved contours.

The "Programmable contour accuracy" function is activated or deactivated via the operations CPRECON and CPRECOF in the NC program.

Syntax

```
CPRECON
...
CPRECOF
```

Meaning

CPRECON: G function call: Switch "Programmable contour accuracy" **on**
Effective: Modal

CPRECOF: G function call: Switch "Programmable contour accuracy" **off**
Effective: Modal

Together CPRECON and CPRECOF form the G function group 39 (programmable contour accuracy).

Note

The user can specify a minimum velocity for the path feedrate via the setting data $SC_MINFEED (minimum path feedrate with CPRECON).

The feedrate is not limited below this value, unless a lower F value has been programmed or the dynamic limits of the axes require a lower path velocity.

Note

The "Programmable contour accuracy" function only considers the geometry axes of the path. It has no effect on the velocities of positioning axes.

Example

```
Program code                Comment
N10 G0 X0 Y0
N20 CPRECON                 ; Activating the "Programmable contour accuracy".
N30 G1 G64 X100 F10000      ; Machining with10 m/min in the continuous-path mode.
N40 G3 Y20 J10              ; Automatic feedrate limitation in the circular block.
N50 G1 X0                   ; Feedrate without limitation again (10 m/min).
...
N100 CPRECOF                ; Deactivating the "Programmable contour accuracy".
N110 G0 ...
```

References

For the programming of CTOL, see "Programmable contour/orientation tolerance (CTOL, OTOL, ATOL) (Page 488)"

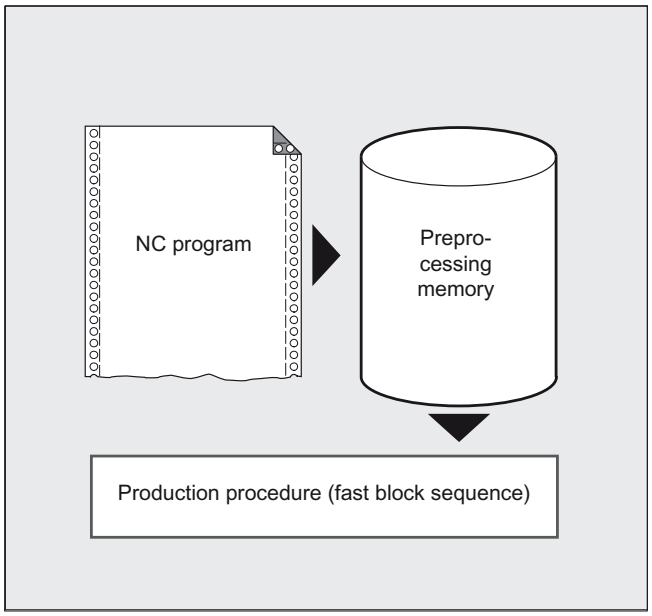
For more detailed information on the "Programmable contour accuracy" function, see:

Function Manual, Special Functions; Contour Tunnel Monitoring (K6), Section: "Programmable contour accuracy"

10.6 Program sequence with preprocessing memory (STOPFIFO, STARTFIFO, FIFOCTRL, STOPRE)

Function

Depending on its expansion level, the control system has a certain quantity of so-called preprocessing memory in which prepared blocks are stored prior to program execution and then output as high-speed block sequences while machining is in progress. These sequences allow short paths to be traversed at a high velocity. Provided that there is sufficient residual control time available, the preprocessing memory is always filled.



Designate machining step

The beginning and end of the machining step to be buffered in the preprocessing memory are identified in the part program with `STOPFIFO` and `STARTFIFO` respectively. The processing of the preprocessed and buffered blocks starts only after the `STARTFIFO` command or if the preprocessing memory is full.

Automatic preprocessing memory control

Automatic preprocessing memory control is called with the `FIFOCTRL` command. `FIFOCTRL` initially works just like `STOPFIFO`. Whatever the programming, processing will not start until the preprocessing memory is full. However, the response to the emptying of the preprocessing memory does differ: With `FIFOCTRL`, the path velocity is reduced increasingly once the fill level reaches 2/3 in order to prevent complete emptying and deceleration to standstill.

Preprocessing stop

Programming the STOPRE command in a block will stop block preprocessing and buffering. The following block is not executed until all preprocessed and saved blocks have been executed in full. The preceding block is halted in exact stop (as with G9).

NOTICE
Program abort If tool offset or spline interpolations are active, a STOPRE command should not be programmed, as this will lead to contiguous block sequences being interrupted.

Syntax

Table 10- 1 Identify machining step:

```
STOPFIFO
...
STARTFIFO
```

Table 10- 2 Automatic preprocessing memory control:

```
...
FIFOCTRL
...
```

Table 10- 3 Preprocessing stop:

```
...
STOPRE
...
```

Note

The STOPFIFO, STARTFIFO, FIFOCTRL, and STOPRE commands have to be programmed in a separate block.

Meaning

STOPFIFO:	STOPFIFO identifies the start of a machining step to be buffered in the preprocessing memory. STOPFIFO stops processing and fills the preprocessing memory until: • STARTFIFO or STOPRE is detected or • The preprocessing memory is full or • The end of the program is reached
STARTFIFO:	STARTFIFO starts rapid processing of the machining step; the preprocessing memory is filled in parallel to this.
FIFOCTRL:	Activation of automatic preprocessing memory control
STOPRE:	Stop preprocessing

Note

The preprocessing memory is not filled or filling is interrupted if the machining step contains commands that require unbuffered operation (search for reference, measuring functions, etc.).

Note

The control generates an internal preprocessing stop in the event of access to status data ($SA...).

Example: Stop preprocessing

```
Program code                                  Comment
...
N30 MEAW=1 G1 F1000 X100 Y100 Z50             ; Measurement block with probe at first
                                              measuring input and linear
                                              interpolation.
N40 STOPRE                                    ; Preprocessing stop.
...
```

10.7 Program sections that can be conditionally interrupted (DELAYFSTON, DELAYFSTOF)

Function

Conditionally interruptible part program sections are called stop delay sections. No **stopping** should occur and the **feed** should not be changed within certain program sections. Essentially, short program sections - e.g. for machining a thread - should be protected from almost all stop events. Stops do not take effect until the program section has been completed.

Syntax

```
DELAYFSTON
...
DELAYFSTOF
```

Note

The DELAYFSTON and DELAYFSTOF commands are programmed separately in a part program line.

Meaning

DELAYFSTON:	Define a start of a range in which "soft" stops are delayed up to the end of the stop delay section.
DELAYFSTOF:	Define the end of the stop delay section

Note

DELAYFSTON and DELAYFSTOF are only permitted in part programs, not in synchronized actions.

Note

For MD11550 $MN_STOP_MODE_MASK bit 0 = 0 (default), a stop delay section is implicitly defined if G331/G332 is active and a path motion or G4 is programmed.

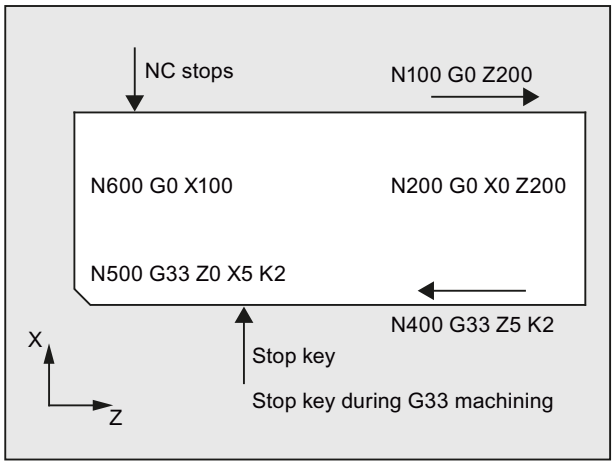
Examples

Example 1: Nesting stop delay sections in two program levels

```
Program code                    Comment
N10010 DELAYFSTON()             ; Blocks with N10xxx program level 1.
N10020 R1 = R1 + 1
N10030 G4 F1                    ; Stop delay section starts.
...
N10040 subprogram2
...
...                             ; Interpretation of subprogram 2
N20010 DELAYFSTON()             ; Ineffective, repeated start, 2nd level.
...
N20020 DELAYFSTOF()             ; Ineffective, end at another level.
N20030 RET
N10050 DELAYFSTOF()             ; Stop delay section end at the same level.
...
N10060 R2 = R2 + 2
N10070 G4 F1                    ; Stop delay section ends. From now, stops act
                                  immediately.
```

Example 2

The following program block is repeated in a loop:



As shown in the diagram, the user presses "Stop" in the stop delay section and the NC starts deceleration outside the stop delay section, i.e. in block N100. That causes the NC to stop at the beginning of N100.

```
Program code
...
N99 MY_LOOP:
N100 G0 Z200
N200 G0 X0 Z200
N300 DELAYFSTON()
N400 G33 Z5 K2 M3 S1000
N500 G33 Z0 X5 K3
N600 G0 X100
N700 DELAYFSTOF()
N800 GOTOB MY_LOOP
```

Further information

Stop events

In the stop delay section, a change in the feedrate and feedrate inhibit are ignored. They only become effective after the stop delay section.

Stop events are divided into:

- "Soft" stop events — Response: delayed
- "Hard" stop events — Response: immediate

Selection of a number of stop events, which induce at least short stopping:

Event name	Response	Interruption parameters
RESET	Immediate	IS: DB21, … DBX7.7 and DB11 DBX20.7
PROG_END	Alarm 16954	NC prog.: `M30`
INTERRUPT	Delayed	IS: FC-9 and ASUP DB10 DBB1
SINGLEBLOCKSTOP	Delayed	Single block mode in the stop delay section is activated: NC stops at the end of the first block outside the stop delay section. Single block already selected before the stop delay section: NST: "NC Stop at block limit" DB21, ... DBX7.2
STOPPROG	Delayed	IS: DB21,… DBX7.3 and DB11 DBX20.5
PROG_STOP	Alarm 16954	NC prog.: `M0` and `M1`
WAITM	Alarm 16954	NC prog.: `WAITM`
WAITE	Alarm 16954	NC prog.: `WAITE`
STOP_ALARM	immediate	Alarm: Alarm configuration STOPBYALARM
RETREAT_MOVE_THREAD	Alarm 16954	NC prog.: Alarm 16954 with `LFON` (stop and fast lift in G33 not possible)
WAITMC	Alarm 16954	NC prog.: `WAITMC`

Event name	Response	Interruption parameters
NEWCONF_PREP_STOP	Alarm 16954	NC prog.: NEWCONF
SYSTEM_SHUTDOWN	Immediate	System shutdown with 840Di sl
ESR	Delayed	Extended stop and retract
EXT_ZERO_POINT	Delayed	External zero offset
STOPRUN	Alarm 16955	OPI: PI "_N_FINDST" STOPRUN

Explanation of the responses:

Immediate ("hard" stop event)	Stops immediately even in stop delay section.
Delayed ("soft" stop event)	Does not stop (even short-term) until after stop delay section.
Alarm 16954	Program is aborted because illegal program commands have been used in stop delay section.
Alarm 16955	Program is continued, an illegal action has taken place in the stop delay section.
Alarm 16957	The program section (stop delay section) enclosed by DELAYFSTON and DELAYFSTOF could not be activated. Every stop will take effect immediately in the section and is not subject to a delay.

For a list of other responses to stop events, see:
References:
Function Manual, Basic Functions; Mode Group, Channel, Program Operation, Reset Behavior (K1)

Advantages of the stop delay section

A program section is processed without a drop in velocity.

If the user aborts the program after a stop with RESET, the aborted program block is after the protected section. This program block is a suitable search target for a subsequent block search.

The following main run axes are not stopped as long as a stop delay section is in progress:

- Command axes and
- Positioning axes that travel with POSA

Part program command G4 is permitted in a stop delay section whereas other part program commands that cause a temporary stop (e.g., WAITM) are not permitted.

Like a path movement, G4 activates the stop delay section and/or keeps it active.

Example: Feedrate intervention

If the override is reduced to 6% before a stop delay section, the override becomes active in the stop delay section.

If the override is reduced from 100% to 6% in the stop delay section, the stop delay section is completed with 100% and beyond that the program continues with 6%.

The feed disable has no effect in the stop delay section; the program does not stop until after the stop delay section.

Overlapping/nesting

If two stop delay sections overlap, one from the NC commands and the other from machine data MD11550 $MN_STOP_MODE_MASK, the largest possible stop delay section will be generated.

The following features regulate the interaction between NC commands DELAYFSTON and DELAYFSTOF with nesting and end of subprogram:

- DELAYFSTOF is activated implicitly at the end of the subprogram in which DELAYFSTON is called.
- DELAYFSTON in a stop delay section has no effect.
- If subprogram 1 calls subprogram 2 in a stop delay section, the whole of subprogram 2 is a stop delay section. In particular, DELAYFSTOF in subprogram 2 has no effect.

Note

REPOSA is an end of subprogram command and DELAYFSTON is always deselected.

If a "hard" stop event coincides with the "stop delay section", the entire "stop delay section" is deselected! Thus, if any other stop occurs in this program section, it will be stopped immediately. A new program setting (new DELAYFSTON) must be made in order to start a new stop delay section.

If the Stop key is pressed before the stop delay section and the NCK must travel into the stop delay section for braking, the NCK will stop in the stop delay section and the stop delay section will remain deselected!

A stop delay section entered with an override of 0% will **not** be accepted!

This applies to all "soft" stop events.

STOPALL can be used to decelerate in the stop delay section. A STOPALL, however, immediately activates all other stop events that were previously delayed.

System variables

A stop delay section can be detected in the part program with $P_DELAYFST. If bit 0 of the system variables is set to 1, part program processing is now in a stop delay section.

A stop delay section can be detected in synchronized actions with $AC_DELAYFST. If bit 0 of the system variables is set to 1, part program processing is now in a stop delay section.

Compatibility

The default setting of machine data MD11550 $MN_STOP_MODE_MASK bit 0 = 0 triggers implicit stop delay section during the G code group G331/G332 and when a path movement or G4 is programmed.

Bit 0 = 1 permits a stop during a G code group G331/G332 and when a path movement or G4 is programmed. The `DELAYFSTON/DELAYFSTOF` commands must be used to define a stop delay section.

10.8 Prevent program position for SERUPRO (IPTRLOCK, IPTRUNLOCK)

Function

For some complicated mechanical situations on the machine it is necessary to the stop block search SERUPRO.

By using a programmable interruption pointer it is possible to intervene before an untraceable point with "Search at point of interruption".

It is also possible to define untraceable sections in part program sections that the NCK cannot yet re-enter. When the program is interrupted, the NCK notes the last block that was processed that can then be searched for via the HMI operator interface.

Syntax

```
IPTRLOCK
IPTRUNLOCK
```

The commands are located in a part program line and allow a programmable interruption pointer

Meaning

`IPTRLOCK`	Start of untraceable program section
`IPTRUNLOCK`	End of untraceable program section

Both commands are only permitted in part programs, but **not** in synchronous actions.

Example

Nesting of untraceable program sections in two program levels with implicit IPTRUNLOCK. Implicit IPTRUNLOCK in subprogram 1 ends the untraceable section.

```
Program code                    Comment
N10010 IPTRLOCK()
N10020 R1 = R1 + 1
N10030 G4 F1                    ; Hold block of the search-suppressed program
                                  section starts.
...
N10040 subprogram2
...                             ; Interpretation of subprogram 2
N20010 IPTRLOCK ()              ; Ineffective, repeated start.
...
N20020 IPTRUNLOCK ()            ; Ineffective, end at another level.
N20030 RET
...
N10060 R2 = R2 + 2
N10070 RET                      ; End of search-suppressed program section.
N100 G4 F2                      ; Main program is continued.
```

The interruption pointer then produces an interruption at 100 again.

Acquiring and finding untraceable sections

Non-searchable program sections are identified with language commands IPTRLOCK and IPTRUNLOCK.

Command IPTRLOCK freezes the interruption pointer at a single block executable in the main run (SBL1). This block will be referred to as the hold block below. If the program is aborted after IPTRLOCK, this hold block can be searched for from the HMI user interface.

Continuing from the current block

The interruption pointer is placed on the current block with IPTRUNLOCK as the interruption point for the following program section.

Once the search target is found a new search target can be repeated with the hold block.

An interrupt pointer edited by the user must be removed again via the HMI.

Rules for nesting

The following features regulate the interaction between NC commands `IPTRLOCK` and `IPTRUNLOCK` with nesting and end of subroutine:

1. `IPTRLOCK` is activated implicitly at the end of the subroutine in which `IPTRUNLOCK` is called.
2. `IPTRLOCK` in an untraceable section has no effect.
3. If subroutine 1 calls subroutine 2 in an untraceable section, the whole of subroutine 2 remains untraceable. `IPTRUNLOCK` in particular has no effect in subroutine 2.

For more information, see
/FB1/ Function Manual, Basic Functions; Mode Group, Channel, Program Operation Mode (K1).

System variables

An untraceable section can be detected in the parts program with `$P_IPTRLOCK`.

Automatic interrupt pointer

The automatic interrupt pointer automatically defines a previously defined coupling type as untraceable. The machine data for

- electronic gearbox with `EGON`
- axial leading value coupling with `LEADON`

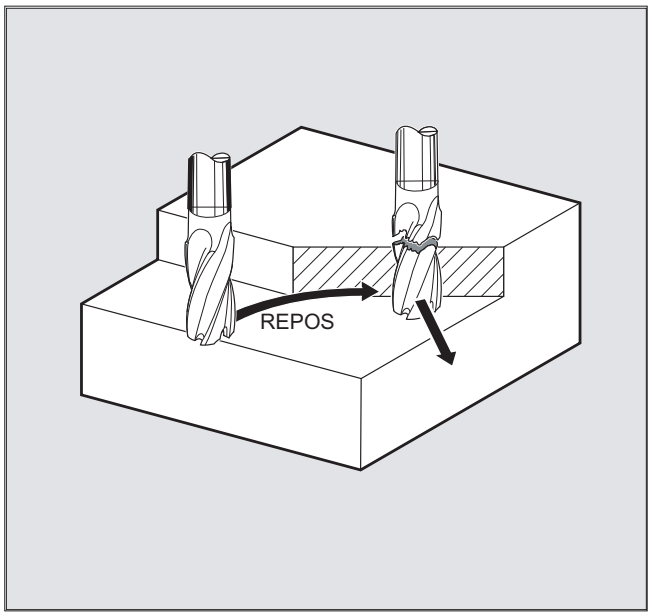
are used to activate the automatic interrupt pointer. If the programmed interrupt pointer and interrupt pointer activated with automatic interrupt pointers overlap, the largest possible untraceable section will be generated.

10.9 Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL)

Function

If you interrupt the program run and retract the tool during the machining operation because, for example, the tool has broken or you wish to check a measurement, you can reposition at any selected point on the contour under control by the program.

The REPOS command acts in the same way as a subprogram return jump (e.g. via M17). Blocks programmed after the command in the interrupt routine are not executed.



For information on interrupting program runs, see also "Interrupt routine (ASUB) (Page 121)".

Syntax

```
REPOSA RMIBL DISPR=…
REPOSA RMBBL
REPOSA RMEBL
REPOSA RMNBL
REPOSL RMIBL DISPR=…
REPOSL RMBBL
REPOSL RMEBL
REPOSL RMNBL
REPOSQ RMIBL DISPR=… DISR=…
REPOSQ RMBBL DISR=…
REPOSQ RMEBL DISR=…
REPOSQA DISR=…
REPOSH RMIBL DISPR=… DISR=…
REPOSH RMBBL DISR=…
REPOSH RMEBL DISR=…
REPOSHA DISR=…
```

Meaning

Approach path

REPOSA:	Approach along line on all axes
REPOSL:	Approach along line
REPOSQ DISR=… :	Approach along quadrant with radius DISR
REPOSQA DISR=… :	Approach on all axes along quadrant with radius DISR
REPOSH DISR=… :	Approach along semi-circle with diameter DISR
REPOSHA DISR=… :	Approach on all axes along semi-circle with diameter DISR

Repositioning point

`RMIBL`:	Approach interruption point
`RMIBL DISPR=…`:	Entry point at distance DISPR in mm/inch in front of interruption point
`RMBBL`:	Approach block start point
`RMEBL`:	Approach end of block
`RMEBL DISPR=…` :	Approach block end point at distance DISPR in front of end point
`RMNBL`:	Approach at nearest path point
`A0 B0 C0` :	Axes in which approach is to be made

Note

Compatibility

In order to remain compatible with older software versions, you can still program the REPOS approach mode via the modal G commands RMI, RMB, RME and RMN. You must make sure to program the ASUB with SAVE attribute in the PROC statement. Otherwise the modal REPOS approach mode, if it differs from the RMI default, would also influence following repositioning procedures unintentionally.

Example: Approach along a straight line, REPOSA, REPOSL

The tool approaches the repositioning point along a straight line.

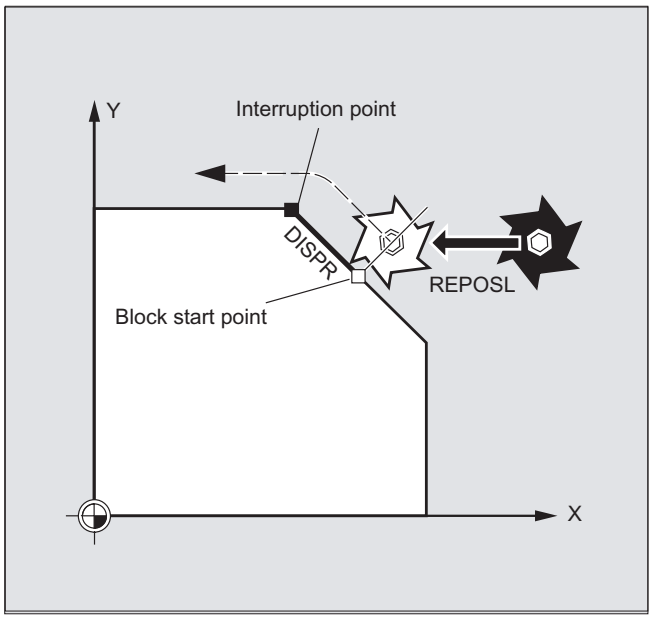
All axes are automatically traversed with command REPOSA. With REPOSL you can specify which axes are to be moved.

Example:

```
REPOSL RMIBL DISPR=6 F400
```

or

```
REPOSA RMIBL DISPR=6 F400
```

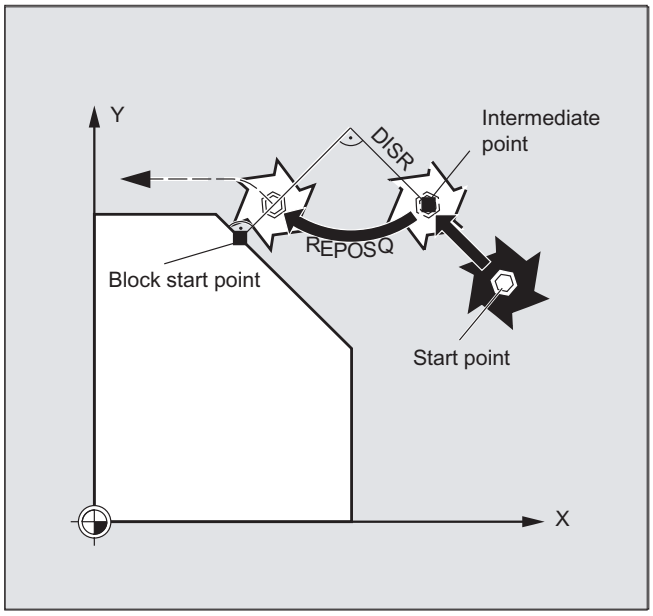


Example: Approach in circle quadrant, REPOSQ, REPOSQA

The tool approaches the repositioning point along a quadrant with a radius of DISR=…. The control automatically calculates the necessary intermediate point between the start and repositioning point.

Example:

```
REPOSQ RMIBL DISR=10 F400
```

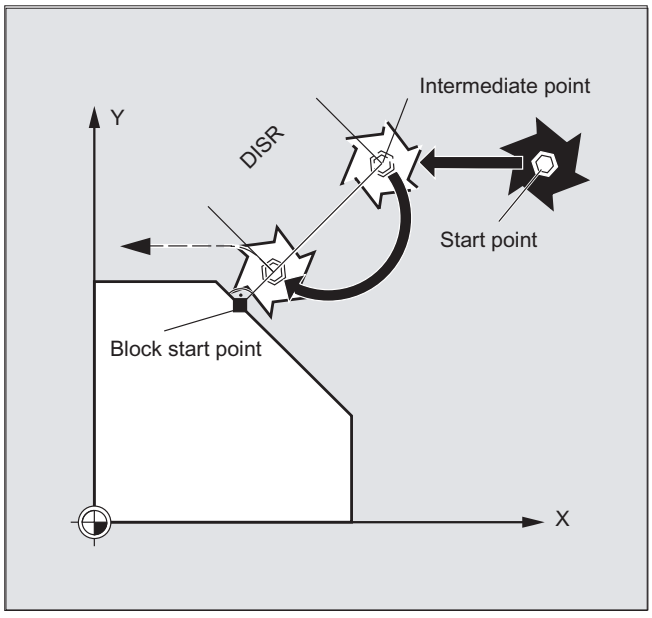


Example: Approach tool in a semicircle, REPOSH, REPOSHA

The tool approaches the repositioning point along a semi-circle with a diameter of DISR=…. The control automatically calculates the necessary intermediate point between the start and repositioning point.

Example:

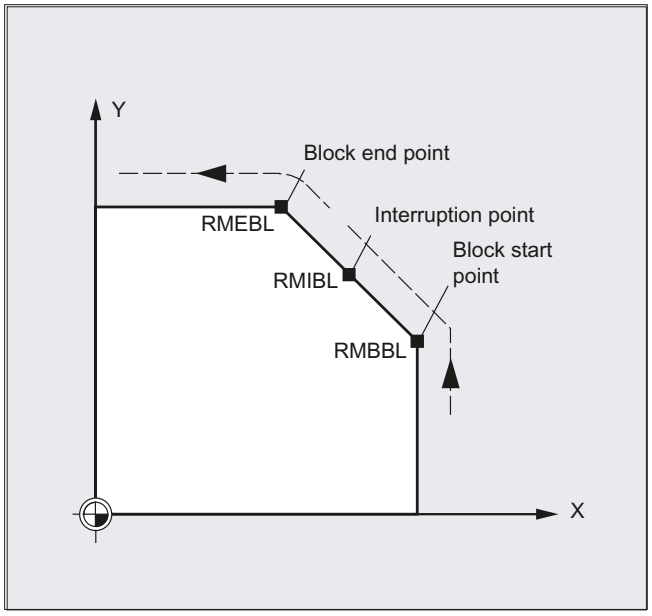
```
REPOSH RMIBL DISR=20 F400
```



Specifying the repositioning point (not for SERUPRO approaching with RMNBL)

With reference to the NC block in which the program run has been interrupted, it is possible to select one of three different repositioning points:

- RMIBL, interruption point
- RMBBL, block start point or last end point
- RMEBL, block end point



RMIBL DISPR=… or RME DISPR=… allows you to select a repositioning point which lies before the interruption point or the block end point.

DISPR=… allows you to describe the contour distance in mm/inch between the repositioning point and the interruption before the end point. Even for high values, this point cannot be further away than the block start point.

If no DISPR=… command is programmed, then DISPR=0 applies and with it the interruption point (with RMIBL) or the block end point (with RMEBL).

DISPR sign

The sign of DISPR is evaluated. In the case of a plus sign, the behavior is as previously.

In the case of a minus sign, approach is behind the interruption point or, with RMBBL, behind the block start point.

The distance between interruption point and approach point depends on the value of DISPR. Even for higher values, this point can lie in the block end point at the maximum.

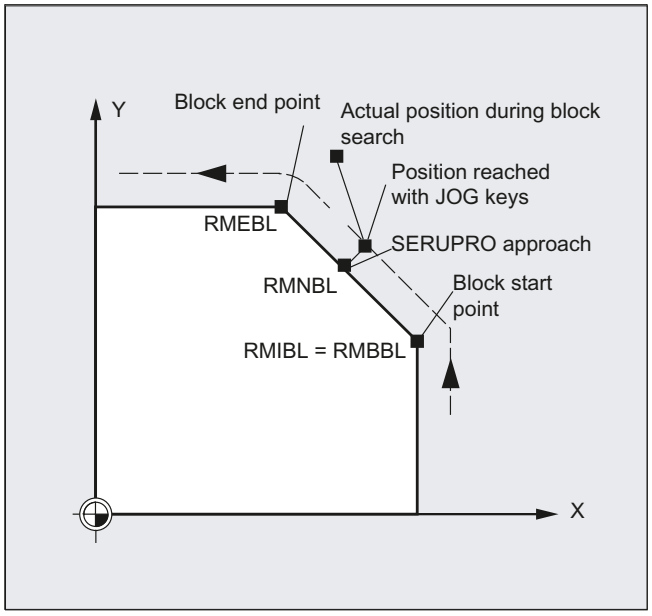
Application example:

A sensor will recognize the approach to a clamp. An ASUB is initiated to bypass the clamp.

Afterwards, a negative DISPR is repositioned on one point behind the clamp and the program is continued.

SERUPRO approach with RMNBL

If an abort is forced during machining at any position, the shortest path from the abort point is approached with SERUPRO approach and RMNBL so that afterward only the distance-to-go is processed. The user starts a SERUPRO process at the interruption block and uses the JOG keys to move in front of the problem component of the target block.



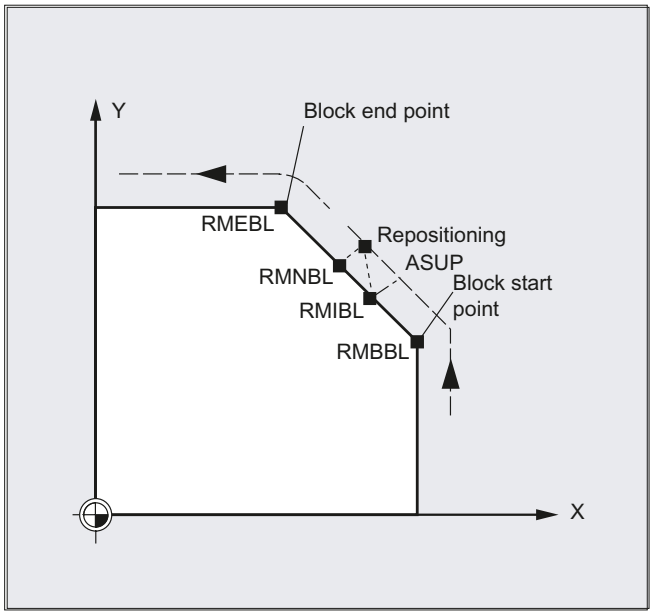
Note

SERUPRO

For SERUPRO, RMIBL and RMBBL are identical. RMNBL is not only limited to SERUPRO, but is generally valid.

Approach from the nearest path point RMNBL

When REPOSA is interpreted, the repositioning block with RMNBL is not started again in full after an interruption, but only the distance-to-go processed. The nearest path point of the interrupted block is approached.



Status for the valid REPOS mode

The valid REPOS mode of the interrupted block can be read with synchronized actions and variable $AC_ REPOS_PATH_MODE:

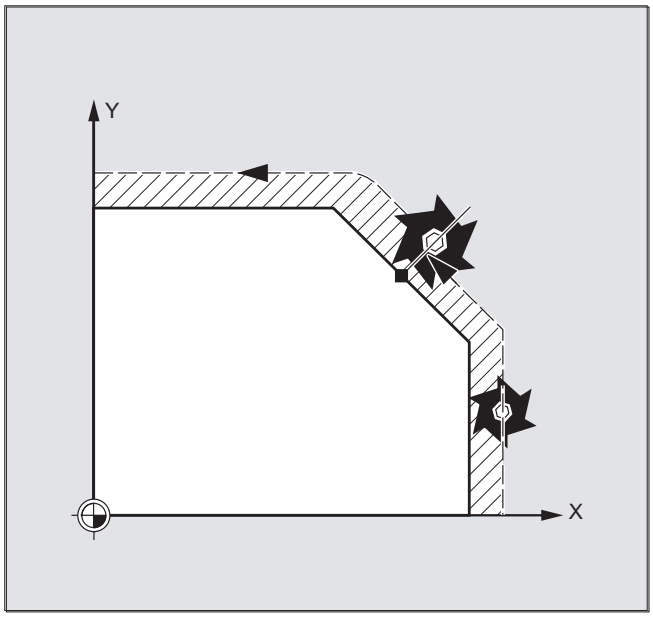
0 Approach not defined
1 RMBBL: Approach to beginning
2 RMIBL: Approach to point of interruption
3 RMEBL: Approach to end of block
4 RMNBL: Approach to next path point of the interrupted block

Approaching with a new tool

The following applies if you have stopped the program run due to tool breakage:

When the new D number is programmed, the machining program is continued with modified tool offset values at the repositioning point.

Where tool offset values have been modified, it may not be possible to reapproach the interruption point. In such cases, the point closest to the interruption point on the new contour is approached (possibly modified by DISPR).



Approach contour

The motion with which the tool is repositioned on the contour can be programmed. Enter zero for the addresses of the axes to be traversed.

The REPOSA, REPOSQA and REPOSHA commands automatically reposition all axes. Individual axis names need not be specified.

When the commands REPOSL, REPOSQ and REPOSH are programmed, all geometry axes are traversed automatically, i.e. they do not have to be specified in the command. All other axes must be specified in the commands.

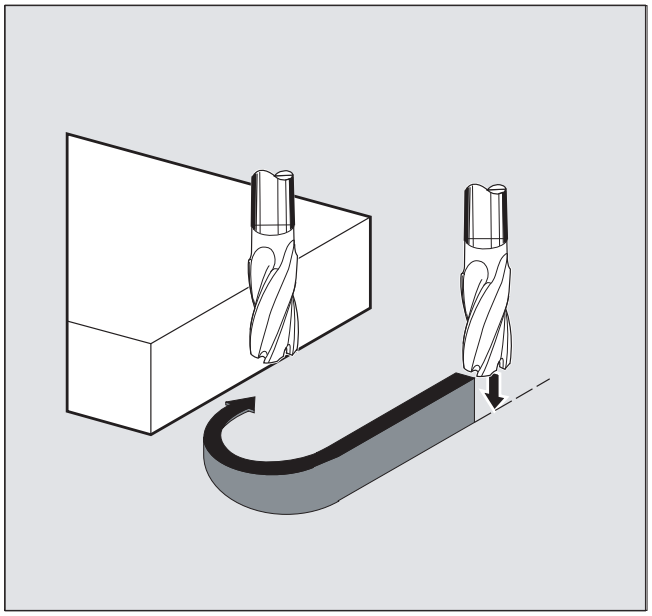
The following applies to the REPOSH and REPOSQ circular motions:

The circle is traversed in the specified working planes G17 to G19.

If you specify the third geometry axis (infeed direction) in the approach block, the repositioning point is approached along a helix in case the tool position and programmed position in the infeed direction do not coincide.

In the following cases, there is an automatic switchover to linear approach REPOSL:

- You have not specified a value for DISR.
- No defined approach direction is available (program interruption in a block without travel information).
- With an approach direction that is perpendicular to the current working plane.



10.10 Influencing the motion control

10.10.1 Percentage jerk correction (JERKLIM)

Function

Using the NC command JERKLIM, the maximum jerk of an axis for path motion - set using machine data - can be reduced or increased in critical program sections.

Requirement

The acceleration mode SOFT must be active.

Effectiveness

The function is effective:

- In the AUTOMATIC operating modes.
- Only on path axes.

Syntax

```
JERKLIM[<axis>]=<value>
```

Meaning

JERKLIM:	Command for jerk correction
<axis>:	Machine axis whose jerk limit value is to be adapted.
<value>:	Percentage correction value, referred to the configured maximum axis jerk for path motion (MD32431 $MA_MAX_AX_JERK). Range of values: 1 ... 200 Value 100 does not influence the jerk.

Note

The behavior of JERKLIM at the end of the part program and channel reset is configured with bit 0 in machine data MD32320 $MA_DYN_LIMIT_RESET_MASK:

- Bit 0 = 0:
  The programmed value for JERKLIM is reset to 100% with channel reset/M30.
- Bit 0 = 1:
  The programmed value for JERKLIM is retained beyond the channel reset/M30.

Example

```
Program code                    Comment
...
N60 JERKLIM[X]=75               ; The axis slide in the X direction should only be
                                  accelerated/decelerated with a maximum of 75% of the
                                  jerk permissible for the axis.
...
```

10.10.2 Percentage velocity correction (VELOLIM)

Function

The maximum possible velocity of an axis or the maximum possible gear-stage-dependent speed of a spindle set via machine data can be reduce with the VELOLIM command in the part program or synchronized action.

Effectiveness

The function is effective:

- In the AUTOMATIC operating modes.
- On path and positioning axes.
- On spindles in spindle/axis operations

Syntax

```
VELOLIM[<axis/spindle>]=<value>
```

Meaning

VELOLIM: Command for velocity correction

<axis/spindle>: Axis or spindle whose velocity or speed limit value should be adapted.

VELOLIM for spindles

Using machine data (MD30455 $MA_MISC_FUNCTION_MASK, bit 6), when programming in the part program, it can be set as to whether VELOLIM is effective independent of whether used as spindle or axis (bit 6 = 1) - or is able to be programmed separately for each operating mode (bit 6 = 0). If they are to be separately effective, then the selection is made using the identifier when programming:

- Spindle identifier S<n> for spindle operating modes
- Axis identifier, e.g. "C", for axis operation

<value>: Percentage correction value

The correction value refers to:

- For axes/spindles in axis operation (MD30455 bit 6 == 0):

  To the configured maximum axis velocity (MD32000 $MA_MAX_AX_VELO).
- For spindles in spindle or axis operation (MD30455 bit 6 == 1):

  To the maximum speed of the active gear unit stage (MD35130 $MA_GEAR_STEP_MAX_VELO_LIMIT[<n>])

Range of values: 1 ... 100

The value 100 does not influence the velocity or speed.

Note

Behavior at the end of the part program and for a channel reset

The behavior of VELOLIM at the end of the part program and channel reset can be set via the machine data: MD32320 $MA_DYN_LIMIT_RESET_MASK, bit 0

Detection of an active speed limitation in spindle operation

A speed limitation via VELOLIM (less than 100 %) can be detected in spindle operation via the following system variables:

- $AC_SMAXVELO (maximum possible spindle speed)
- $AC_SMAXVELO_INFO (identifier for the speed-limiting cause)

Examples

Example 1: Velocity limitation, machine axis

```
Program code                    Comment
...
N70 VELOLIM[X]=80               ; The axis slide in the X direction should only be
                                  traversed with a maximum of 80% of the velocity
                                  permissible for the axis.
...
```

Example 2: Speed limitation, spindle

```
Program code                    Comment
N05 VELOLIM[S1]=90              ; Limiting the maximum speed of spindle 1 to 90% of
                                  1000 rpm.
...
N50 VELOLIM[C]=45               ; Limiting the speed to 45% of 1000 rpm, C is the axis
                                  identifier of S1.
...
```

Machine data settings for spindle 1 (AX5)

- Maximum speed of gear stage 1 = 1000 rpm:
  MD35130 $MA_GEAR_STEP_MAX_VELO_LIMIT[1, AX5] = 1000
- Programming VELOLIM acts together for spindle and axis operation independent of the programmed identifier:
  MD30455 $MA_MISC_FUNCTION_MASK[AX5], bit 6 = 1

10.10.3 Program example for JERKLIM and VELOLIM

The following program presents an application example for the percentage jerk and velocity limit:

```
Program code                          Comments
N1000 G0 X0 Y0 F10000 SOFT G64
N1100 G1 X20 RNDM=5 ACC[X]=20
ACC[Y]=30
N1200 G1 Y20 VELOLIM[X]=5             ; The axis slide in the X direction should
                                        only be traversed with max. 5% of the
                                        velocity permissible for the axis.
JERKLIM[Y]=200                        ; The axis slide in the Y direction can be
                                        accelerated/decelerated with max. 200% of
                                        the jerk permissible for the axis.
N1300 G1 X0 JERKLIM[X]=2              ; The axis slide in the X direction should
                                        only be accelerated/decelerated with max.
                                        2% of the jerk permissible for the axis.
N1400 G1 Y0
M30
```

10.11 Programmable contour/orientation tolerance (CTOL, OTOL, ATOL)

Function

The CTOL, OTOL, and ATOL commands can be used to adapt the machining tolerances defined for the compressor functions (COMPON, COMPCURV, COMPCAD), the smoothing types G642, G643, G645, OST, and the orientation ORISON using machine and setting data in the NC program.

The programmed values are valid until they are reprogrammed or deleted by means of the assignment of a negative value. They are also deleted at the end of a program, in the event of a channel reset, a mode group reset, an NCK reset (warm restart), and POWER ON (cold restart). On deletion of these values, the values from the machine and setting data are restored.

Syntax

```
CTOL=<value>
OTOL=<value>
ATOL[<axis>]=<value>
```

Meaning

CTOL Command for programming the **contour tolerance**

CTOL is valid for:

- All compressor functions
- All rounding types except G641 and G644

<value>: The value for the contour tolerance is specified as a length.

Type: REAL

Unit: inch/mm (dependent on the current dimensions setting)

OTOL Command for programming the **orientation tolerance**

OTOL is valid for:

- All compressor functions
- ORISON orientation smoothing
- All rounding types except G641, G644, OSD

<value>: The value for the orientation tolerance is specified as an angle.

Type: REAL

Unit: degrees

ATOL Command for programming an **axis-specific tolerance**

ATOL is valid for:

- All compressor functions
- ORISON orientation smoothing
- All rounding types except G641, G644, OSD

<axis>: Name of the axis for which an axis tolerance is to be programmed

<value>: The value for the axis tolerance will be specified as a length or an angle dependent on the axis type (linear or rotary axis).

Type: REAL

Unit: For linear axes: inch/mm (dependent on the current dimensions setting)

For rotary axes: degrees

Note

CTOL and OTOL have priority over ATOL.

Supplementary conditions

Scaling frames

Scaling frames affect programmed tolerances in the same way as axis positions; in other words, the relative tolerance remains the same.

Example

```
Program code                    Comment
COMPCAD G645 G1 F10000          ; Activate COMPCAD compressor function.
X... Y... Z...                  ; The machine and setting data is applied here.
X... Y... Z...
X... Y... Z...
CTOL=0.02                       ; A contour tolerance of 0.02 mm is applied
                                  starting from here.
X... Y... Z...
X... Y... Z...
X... Y... Z...
ASCALE X0.25 Y0.25 Z0.25        ; A contour tolerance of 0.005 mm is applied
                                  starting from here.
X... Y... Z...
X... Y... Z...
X... Y... Z...
CTOL=-1                         ; The machine and setting data is applied again
                                  starting from here.
X... Y... Z...
X... Y... Z...
X... Y... Z...
```

Further information

Read tolerance values

For more advanced applications or for diagnostics, the currently valid tolerances for the compressor functions (COMPON, COMPCURV, COMPCAD), the smoothing types G642, G643, G645, OST, and the orientation smoothing ORISON can be read via system variables irrespective of how they might have come about.

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

$AC_CTOL	Contour tolerance effective when the current main run record was preprocessed. If no contour tolerance is effective, `$AC_CTOL` will return the root from the sum of the squares of the tolerances of the geometry axes.
$AC_OTOL	Orientation tolerance effective when the current main run record was preprocessed. If no orientation tolerance is effective, `$AC_OTOL` will return the root from the sum of the squares of the tolerances of the orientation axes during active orientation transformation. Otherwise, it will return the value "-1".

$AA_ATOL[<axis>]	Axis tolerance effective when the current main run record was preprocessed. If no contour tolerance is active, `$AA_ATOL[<geometry axis>]` will return the contour tolerance divided by the root of the number of geometry axes. If an orientation tolerance and an orientation transformation are active `$AA_ATOL[<orientation axis>]` will return the orientation tolerance divided by the root of the number of orientation axes.

Note

If no tolerance values have been programmed, the $A variables will not be differentiated sufficiently to distinguish potential differences in the tolerances of the individual functions, since they can only declare one value.

Circumstances like this can occur if the machine data and the setting data set different tolerances for compressor functions, smoothing and orientation smoothing. The variables then return the greatest value prevailing with regard to the currently active functions.

if, for example, a compressor function is active with an orientation tolerance of 0.1° and ORISON orientation smoothing with 1°, the $AC_OTOL variable will return the value "1". If orientation smoothing is deactivated, only the value "0.1" will remain to be read.

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

$P_CTOL	Programmed contour tolerance
$P_OTOL	Programmed orientation tolerance
$PA_ATOL	Programmed axis tolerance

Note

If no tolerance values have been programmed, the $P variables will return the value "-1".

10.12 Tolerance for G0 motion (STOLF)

G0 tolerance factor

G0 motion (rapid traverse, infeed motion), contrary to workpiece machining, can be implemented with a higher tolerance. This has the advantage that the execution times for G0 motion are shortened.

For G0 motion, the tolerances are set by configuring the G0 tolerance factor (MD20560 $MC_G0_TOLERANCE_FACTOR).

The G0 tolerance factor is only effective, if:

- One of the following functions is active:
  - Compressor function: COMPON, COMPCURV and COMPCAD
  - Smoothing functions: G642 and G645
  - Orientation smoothing: OST
  - Orientation smoothing: ORISON
  - Smoothing for path-relevant orientation: ORIPATH
- Several (≥ 2) consecutive G0 blocks.

  For a single G0 block, the G0 tolerance factor is not effective, as **at the transition** from a non G0 motion to a G0 motion (and vice versa), the "**lower tolerance**" always applies (workpiece machining tolerance)!

Function

The configured G0 tolerance factor (MD20560) can be temporarily overwritten by programming `STOLF` in the part program. In this case, the value in MD20560 is not changed. After a reset or end of part program, the configured tolerance factor is effective again.

Syntax

```
STOLF=<tolerance factor>
```

Meaning

`STOLF`:	Command to program the G0 tolerance factor
`<tolerance factor>`:	G0 tolerance factor The factor can either be greater than 1 or less than 1. However, normally higher tolerances can be set for G0 motion. For `STOLF=1.0` (this corresponds to the configured standard value), for G0 motion, the same tolerances are effective as for non-G0 motion.

System variables

The G0 tolerance factor, effective in the part program or in the actual IPO block, can be read using system variables.

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

  $AC_STOLF Active G0 tolerance factor
  G0 tolerance factor, which was effective when processing the actual main run block.

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

  $P_STOLF Programmed G0 tolerance factor

If no value with STOLF is programmed in the active part program, then these two system variables supply the value set using MD20560 $MC_G0_TOLERANCE_FACTOR.

If no rapid traverse (G0) is active in a block, then these system variables always supply a value of 1.

Example

```
Program code                    Comment
COMPCAD G645 G1 F10000          ; Compressor function COMPCAD
X... Y... Z...                  ; The machine and setting data apply here.
X... Y... Z...
X... Y... Z...
G0 X... Y... Z...
G0 X... Y... Z...               ; Machine data $MC_G0_TOLERANCE_FACTOR (e.g. =3), is
                                  effective here, i.e. a smoothing tolerance of
                                  $MC_G0_TOLERANCE_FACTOR*$MA_COMPRESS_POS_TOL.
CTOL=0.02
STOLF=4
G1 X... Y... Z...               ; A contour tolerance of 0.02mm is applied starting
                                  from here.
X... Y... Z...
X... Y... Z...
G0 X... Y... Z...
X... Y... Z...                  ; From here, a G0 tolerance factor of 4 applies, i.e. a
                                  contour tolerance of 0.08mm.
```

10.13 Block change behavior with active coupling (CPBC)

Function

The `CPBC` command specifies the block change criterion that must be satisfied so that a block change can be executed in the part program with active coupling.

Syntax

```
CPBC[<following axis>] = <criterion>
```

Meaning

`CPBC`:	Block change criterion with active coupling	
`<following axis>`:	Axis identifier of the following axis	
`<criterion>`:	Block change criterion	
	Type:	STRING
	Value	**Meaning:** Block change is performed
	"NOC"	Irrespective of the coupling status
	"IPOSTOP"	For setpoint synchronism
	"COARSE"	For actual value synchronism "coarse"
	"FINE"	For actual value synchronism "fine"

Example

Program code

```
; Block change takes place with:
; - Coupling to following axis X2 == active
; - Setpoint synchronism == active
CPBC[X2]="IPOSTOP"
```

Axis couplings

11

11.1 Coupled motion (TRAILON, TRAILOF)

Function

When a defined leading axis is moved, the coupled motion axes (= following axes) assigned to it traverse through the distances described by the leading axis, allowing for a coupling factor.

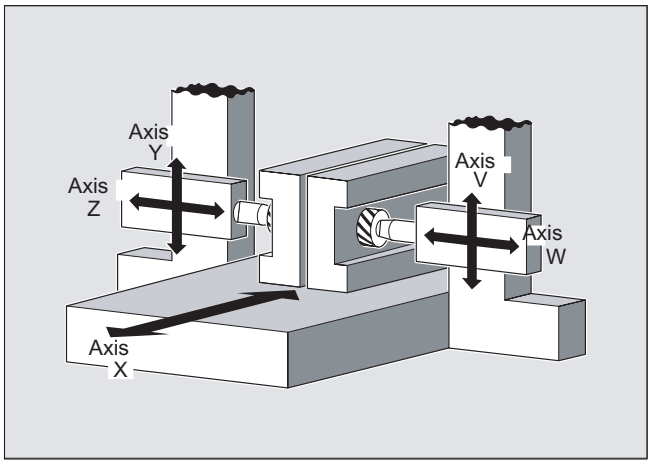
Together, the leading axis and following axis represent coupled axes.

Applications

- Traversal of an axis by means of a simulated axis. The leading axis is a simulated axis and the coupled axis a real axis. In this way, the real axis can be traversed as a function of the coupling factor.
- Two-sided machining with two coupled motion groups:

  1st leading axis Y, coupled motion axis V

  2nd leading axis Z, coupled motion axis W



Syntax

```
TRAILON(<following axis>,<leading axis>,<coupling factor>)
TRAILOF(<following axis>,<leading axis>,<leading axis 2>)
TRAILOF(<following axis>)
```

Meaning

`TRAILON`	Command for activating and defining a coupled axis grouping Effective: Modal
`<following axis>`	Parameter 1: Axis name of trailing axis **Note:** A coupled-motion axis can also act as the leading axis for other coupled-motion axes. In this way, it is possible to create a range of different coupled axis groupings.
`<leading axis>`	Parameter 2: Axis name of trailing axis
`<coupling factor>`	Parameter 3: Coupling factor The coupling factor specifies the desired relationship between the paths of the coupled-motion axis and the leading axis: <coupling factor> = path of coupled-motion axis/path of leading axis Type: REAL Default: 1 The input of a negative value causes the master and coupled axes to traverse in opposition. If a coupling factor is not programmed, then coupling factor 1 automatically applies.

`TRAILOF`	Command for deactivating a coupled axis grouping
	Effective: Modal
	`TRAILOF` with 2 parameters deactivates only the coupling to the specified leading axis:
	`TRAILOF(<following axis>,<leading axis>)`
	If a coupled-motion axis has 2 leading axes, `TRAILOF` can be called with 3 parameters to deactivate both couplings.
	`TRAILOF(<following axis>,<leading axis>,<leading axis 2>)`
	Programming `TRAILOF` without specifying a leading axis produces the same result:
	`TRAILOF(<following axis>)`

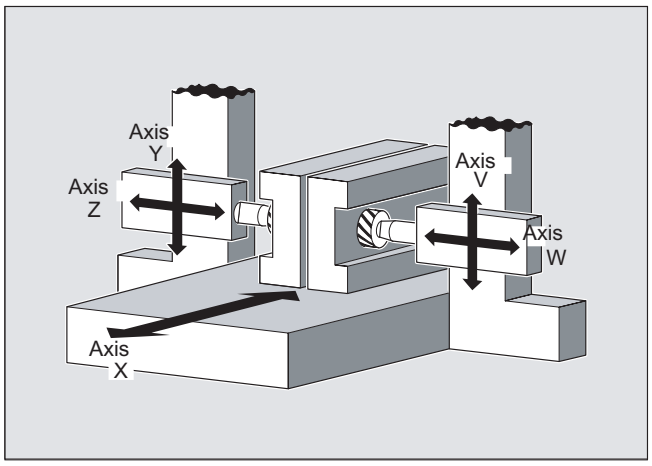
Note

Coupled axis motion is always executed in the base coordinate system (BCS).

The number of coupled axis groupings which may be simultaneously activated is limited only by the maximum possible number of combinations of axes on the machine.

Example

The workpiece is to be machined on two sides with the axis configuration shown in the diagram. To do this, you create two combinations of coupled axes.



Program code	Comment
…	
N100 TRAILON(V,Y)	; Activation of 1st coupled axis grouping
N110 TRAILON(W,Z,-1)	; Activation of 2nd coupled axis grouping, Negative coupling factor: Coupled-motion axis traverses in the opposite direction from leading axis.
N120 G0 Z10	; Infeed of Z and W axes in opposite axial directions.
N130 G0 Y20	; Infeed of Y and V axes in same axis direction.
…	
N200 G1 Y22 V25 F200	; Overlaying of a dependent and independent movement of coupled motion axis V.
…	
TRAILOF(V,Y)	; Deactivation of 1st coupled axis grouping.
TRAILOF(W,Z)	; Deactivation of 2nd coupled axis grouping.

Further information

Axis types

A coupled axis grouping can consist of any desired combinations of linear and rotary axes. A simulated axis can also be defined as a leading axis.

Coupled-motion axes

Up to two leading axes can be assigned simultaneously to a trailing axis. The assignment is made in different combinations of coupled axes.

A coupled-motion axis can be programmed with the full range of available motion commands (`G0`, `G1`, `G2`, `G3`, etc.). The coupled axis not only traverses the independently defined paths, but also those derived from its leading axes on the basis of coupling factors.

Dynamics limit

The dynamics limit is dependent on the type of activation of the coupled axis grouping:

- Activation in part program

  If activation is performed in the part program and all leading axes are active as program axes in the activated channel, the dynamic response of all coupled-motion axes is taken into account during traversing of the leading axis to avoid overloading the coupled-motion axes.

  If activation is performed in the part program with leading axes that are not active as program axes in the activating channel ($AA_TYP ≠ 1), then the dynamic response of the coupled-motion axes is not taken into account during traversing of the leading axis. This can cause the overloading of coupled-motion axes with a dynamic response which is less than that required for the coupling.

- Activation in synchronized action

  If activation is performed in a synchronized action, the dynamic response of the coupled-motion axes is not taken into account during traversing of the leading axis. This can cause the overloading of coupled-motion axes with a dynamic response which is less than that required for the coupling.

⚠ CAUTION

Axis overload

If a coupled axis grouping is activated:

- In synchronized actions
- In the part program with leading axes that are not program axes in the channel of the coupled-motion axes

It is the specific responsibility of the user / machine manufacturer to take suitable action to ensure that the traversing of the leading axis will not cause the overloading of the coupled-motion axes.

Coupling status

The coupling status of an axis can be checked in the part program with the system variable:

$AA_COUP_ACT[<axis>]

Value	Meaning
0	No coupling active
8	Coupled motion active

Display of distance-to-go of the coupled-motion axis for modulo rotary axes

If the leading and coupled-motion axes are modulo rotary axes, traversing movements in the leading axis from n * 360° with n = 1, 2, 3 ... , add up in the distance-to-go display of the coupled-motion axis until the coupling is switched off.

Example: Program section with TRAILON and leading axis B and following axis C

```
Program code                    Comment
TRAILON(C,B,1)                  ; Activate coupling
G0 B0                           ; Starting position
                                ; Distance-to-go display at block start:
G91 B360                        ; B=360, C=360
G91 B720                        ; B=720, C=1080
G91 B360                        ; B=360, C=1440
```

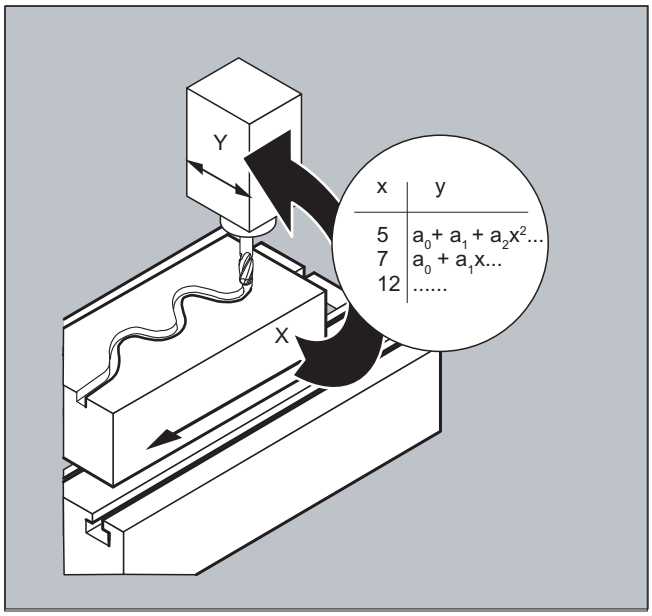
11.2 Curve tables (CTAB)

Function

Curve tables can be used to program position and velocity relationships between two axes (leading and following axis). Curve tables are defined in the part program.

Application

Curve tables replace mechanical cams. The curve table forms the basis for the axial master value coupling by creating the functional relationship between the leading and the following value: With appropriate programming, the control calculates a polynomial that corresponds to the cam from the relative positions of the leading and following axes.

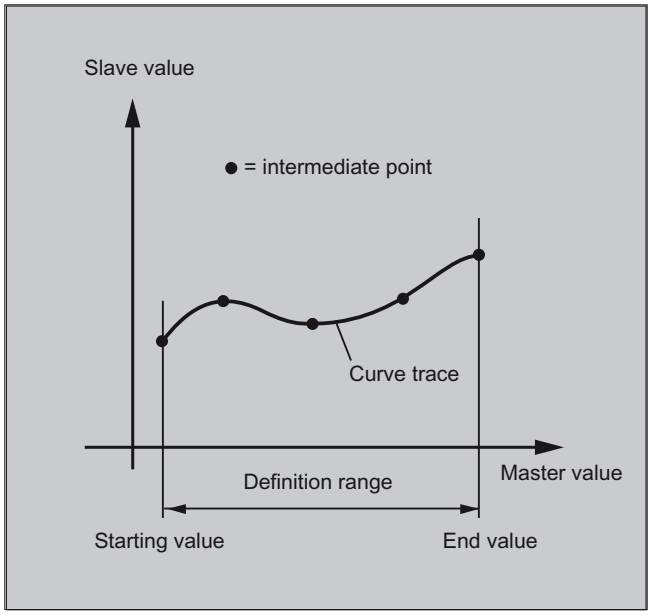


11.2.1 Define curve tables (CTABDEF, CATBEND)

Function

A curve table represents a part program or a section of a part program enclosed by `CTABDEF` at the start and `CTABEND` at the end.

Within this part program section, unique following axis positions are assigned to individual positions of the leading axis using motion operations; these following axis positions are used as intermediate points when calculating the curve definition in the form of a polynomial up to the 5th order.



Requirement

The MD must be configured accordingly to ensure that sufficient memory space is reserved for the definition of curve tables (→ machine manufacturer).

Syntax

```
CTABDEF(<following axis>,<leading axis>,<n>,<periodicity>[,<memory
location>])
...
CTABEND
```

Meaning

`CTABDEF( )`	Start of curve table definition
`CTABEND`	End of curve table definition
`<following axis>`	Axis whose motion is to be calculated using the curve table
`<leading axis>`	Axis providing the master values for the calculation of the following axis motion

<n>	Number (**ID**) of curve table The number of a curve table is unique and independent of the memory location. It is not possible for there to be tables with the same number in the static and dynamic NC memory.
<periodicity>	Table periodicity 0 Table is non-periodic (table is processed only once, even for rotary axes) 1 Table is periodic with regard to the leading axis 2 Table is periodic with regard to leading axis and following axis
<memory location>	Specification of memory location (optional) "SRAM" The curve table is created in the **static** NC memory. "DRAM" The curve table is created in the **dynamic** NC memory. **Note:** If a value is not programmed for this parameter, the default memory location set with MD20905 $MC_CTAB_DEFAULT_MEMORY_TYPE is used.

Note

Overwrite

A curve table is overwritten as soon as its number (<n>) is used in another table definition (exception: the curve table is in active in an axis coupling or locked with CTABLOCK). **No warning is output when curve tables are overwritten.**

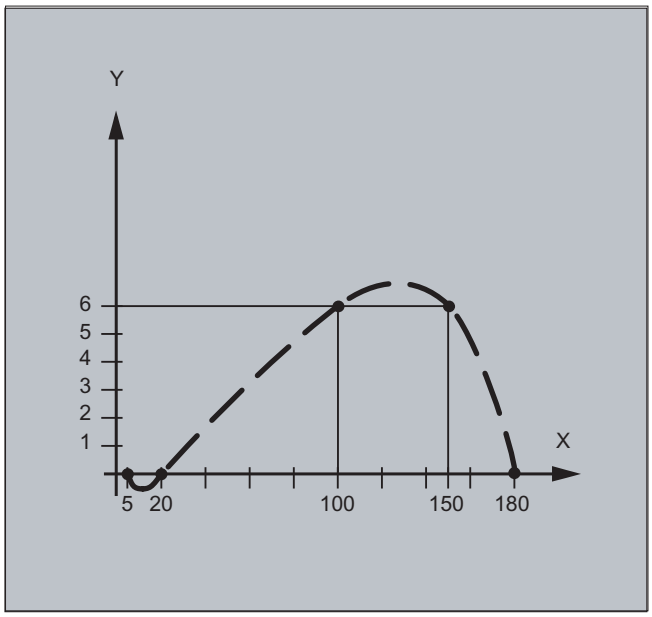
Examples

Example 1: Program section as curve table definition

A program section is to be used unchanged for defining a curve table. The STOPRE command for preprocessing stop can remain and is reactivated immediately as soon as the program section is no longer being used for table definition and CTABDEF and CTABEND have been removed.

```
Program code                    Comment
…
CTABDEF(Y,X,1,1)                ; Definition of a curve table.
…
IF NOT ($P_CTABDEF)
STOPRE
ENDIF
…
CTABEND
```

Example 2: Definition of a non-periodic curve table



Program code	Comment
N100 CTABDEF(Y,X,3,0)	; Beginning of the definition of a ;non-periodic curve table with number 3.
N110 X0 Y0	; 1st motion operation, defines the starting values and 1st intermediate point: Master value: 0, Following value: 0
N120 X20 Y0	; 2nd intermediate point Master value: 0…20, Following value: starting value…0
N130 X100 Y6	; 3rd intermediate point: Master value: 20…100, Following value: 0…6
N140 X150 Y6	; 4th intermediate point: Master value: 100…150, Following value: 6…6
N150 X180 Y0	; 5th intermediate point: Master value: 150…180, Following value: 6…0
N200 CTABEND	; End of definition. The curve table is generated in its internal representation as a polynomial of up to the 5th order. The calculation of the curve definition with the specified intermediate points is dependent on the modally selected interpolation type (circular, linear, spline interpolation). The part program state before starting the definition is restored.

Example 3: Definition of a periodic curve table

Definition of a periodic curve table with number 2, master value range 0 to 360, following axis motion from 0 to 45 and back to 0:

```
Program code                                          Comment
N10 DEF REAL DEPPOS
N20 DEF REAL GRADIENT
N30 CTABDEF(Y,X,2,1)                                  ; Start of definition
N40 G1 X=0 Y=0
N50 POLY
N60 PO[X]=(45.0)
N70 PO[X]=(90.0) PO[Y]=(45.0,135.0,-90)
N80 PO[X]=(270.0)
N90 PO[X]=(315.0) PO[Y]=(0.0,-135.0,90)
N100 PO[X]=(360.0)
N110 CTABEND                                          ; End of definition.
;Test of the curve by coupling Y to X:
N120 G1 F1000 X0
N130 LEADON(Y,X,2)
N140 X360
N150 X0
N160 LEADOF(Y,X)

N170 DEPPOS=CTAB(75.0,2,GRADIENT)                     ; Read the table function for
                                                        master value 75.0.
N180 G0 X75 Y=DEPPOS                                  ; Positioning leading and following
                                                        axes.
;After activating the coupling, no synchronization of the following axis is
required.
N190 LEADON(Y,X,2)
N200 G1 X110 F1000
N210 LEADOF(Y,X)
N220 M30
```

Further information

Starting and end value of the curve table

The starting value for the beginning of the definition range of the curve table are the first associated axis positions specified (the first traverse statement) within the curve table definition. The end value of the definition range of the curve table is determined in accordance with the last traverse command.

Available language scope

Within the definition of the curve table, you have use of the entire NC language.

Note

The following entries are not permitted in curve table definitions:

- Preprocessing stop
- Jumps in the leading axis movement (e.g. on changing transformations)
- Traverse statement for the following axis only
- Reversal of the leading axis, i.e. position of the leading axis must always be unique
- CTABDEF and CTABEND operation on different program levels.

Effectiveness of modal operations

All modal statements that are made within the curve table definition are invalid when the table definition is completed. The part program in which the table definition is made is therefore before and after the table definition in the same state.

Assignments to R-parameters

Assignments to R-parameters in the table definition are reset after CTABEND.

Example:

```
Program code                    Comments
...
R10=5 R11=20                    ; R10=5
...
CTABDEF
G1 X=10 Y=20 F1000
R10=R11+5                       ; R10=25
X=R10
CTABEND
...                             ; R10=5
```

Activating ASPLINE, BSPLINE, CSPLINE

If an ASPLINE, BSPLINE or CSPLINE is activated within a curve table definition CTABDEF ... CTABEND, at least one starting point should be programmed before this spline activation. Immediate activation after CTABDEF should be avoided, otherwise the spline will depend on the current axis position before the curve table definition.

Example:

```
Program code
...
CTABDEF(Y,X,1,0)
X0 Y0
```

```
Program code
ASPLINE
X=5 Y=10
X10 Y40
...
CTABEND
```

Repeated use of curve tables

The functional relationship between the leading axis and the following axis calculated using the curve table will be retained under the selected table number after the end of the part program and POWER OFF if the table has been saved to the static NC memory (SRAM).

A table created in the dynamic memory (DRAM) will be deleted on POWER ON and may have to be regenerated.

Once created, the curve table can be applied to any axis combinations of leading and following axis and is independent of the axes used to create the curve table.

Overwriting curve tables

A curve table is overwritten as soon as its number is used in another table definition.

Exception: A curve table is either active in an axis coupling or locked with `CTABLOCK`.

Note

No warning is output when curve tables are overwritten.

Curve table definition active?

The `$P_CTABDEF` system variable can be used at any time in the part program to check whether a curve table definition is active.

Revoking the curve table definition

Once the operations relating to the curve table definition have been excluded, the part program section can be used as a real part program again.

Loading curve tables using "Execution from external source"

If curve tables are executed from an external source, the selection of the size of the reload buffer (DRAM) in MD18360 $MN_MM_EXT_PROG_BUFFER_SIZE has to support the simultaneous storage of the entire curve table definition in the reload buffer. If it is not, part program processing will be canceled with an alarm.

Jumps in the following axis

Depending on the setting in machine data
MD20900 $MC_CTAB_ENABLE_NO_LEADMOTION
, jumps in the following axis may be tolerated if a movement is missing in the leading axis.

11.2.2 Check for presence of curve table (CTABEXISTS)

Function

The CTABEXISTS command can be used to check if a specific curve table number is present in the NC memory.

Syntax

```
CTABEXISTS(<n>)
```

Meaning

CTABEXISTS	Checks for the presence of curve table number <n> in the static or dynamic NC memory. 0 Table does not exist 1 Table exists
<n>	Number (**ID**) of curve table

11.2.3 Delete curve tables (CTABDEL)

Function

CTABDEL can be used to delete curve tables.

Note

Curve tables that are active in an axis coupling cannot be deleted.

Syntax

```
CTABDEL(<n>)
CTABDEL(<n>,<m>)
CTABDEL(<n>,<m>,<memory location>)
CTABDEL()
CTABDEL(,,<memory location>)
```

Meaning

`CTABDEL`	Command for deleting curve tables
`<n>`	Number (**ID**) of the curve table to be deleted When a curve table range `CTABDEL(<n>,<m>)` is deleted, `<n>` is used to specify the number of the first curve table in the range.
`<m>`	When a curve table range `CTABDEL(<n>,<m>)` is deleted, `<m>` is used to specify the number of the last curve table in the range. `<m>` has to be greater than `<n>`.
`<memory location>`	Specification of memory location (optional) In the case of deletion **without** a memory location being specified, the specified curve tables are deleted in the static and the dynamic NC memory. In the case of deletion **with** a memory location being specified, of the specified curve tables, only those located in the specified memory location are deleted. The rest are retained. `"SRAM"` Deletion in the **static** NC memory `"DRAM"` Deletion in the **dynamic** NC memory

If `CTABDEL` is programmed without specification of the curve table to be deleted, then **all** curve tables or all curve tables in the specified memory will be deleted:

`CTABDEL()`	Deletes all curve tables in the static and the dynamic NC memory
`CTABDEL(,,"SRAM")`	Deletes all curve tables in the static NC memory
`CTABDEL(,,"DRAM")`	Deletes all curve tables in the dynamic NC memory

Note

If, in the case of multiple deletion with `CTABDEL(<n>,<m>)` or `CTABDEL()`, at least one of the of the curve tables to be deleted is active in a coupling, the delete command will not be executed; in other words, **none** of the addressed curve tables will be deleted.

11.2.4 Locking curve tables to prevent deletion and overwriting (CTABLOCK, CTABUNLOCK)

Function

Locks can be set to protect curve tables against unintentional deletion and overwriting. Once a lock has been set, it can be revoked at any time.

Syntax

Lock:

```
CTABLOCK(<n>)
CTABLOCK(<n>,<m>)
CTABLOCK(<n>,<m>,<memory location>)
CTABLOCK()
CTABLOCK(,,<memory location>)
```

Unlock:

```
CTABUNLOCK(<n>)
CTABUNLOCK(<n>,<m>)
CTABUNLOCK(<n>,<m>,<memory location>)
CTABUNLOCK()
CTABUNLOCK(,,<memory location>)
```

Meaning

CTABLOCK	Command for **setting** a lock to prevent deletion/overwriting
CTABUNLOCK	Command for **revoking** a lock to prevent deletion/overwriting CTABUNLOCK unlocks the curve tables locked with CTABLOCK. Curve tables which are involved in an active coupling remain locked and cannot be deleted. The lock with CTABLOCK is unlocked as soon as the lock applied due to the active coupling is unlocked when the coupling is deactivated. This table can therefore be deleted. It is not necessary to call CTABUNLOCK again.
<n>	Number (**ID**) of the curve table to be locked/unlocked When a curve table range CTABLOCK(<n>,<m>)/CTABUNLOCK(<n>,<m>) is locked/unlocked, <n> is used to specify the number of the first curve table in the range.
<m>	When a curve table range CTABLOCK(<n>,<m>)/CTABUNLOCK(<n>,<m>) is locked/unlocked, <m> is used to specify the number of the last curve table in the range. <m> has to be greater than <n>.

`<memory location>`	Specification of memory location (optional) In the case of locking/unlocking **without** a memory location being specified, the specified curve tables are locked/unlocked in the static and the dynamic NC memory. In the case of locking/unlocking **with** a memory location being specified, of the specified curve tables, only those located in the specified memory location are locked/unlocked. The rest are not locked/unlocked. `"SRAM"` Lock/unlock in the **static** NC memory `"DRAM"` Lock/unlock in the **dynamic** NC memory

If `CTABLOCK`/`CTABUNLOCK` is programmed without specification of the curve table to be locked/unlocked, then **all** curve tables or all curve tables in the specified memory will be locked/unlocked:

`CTABLOCK()`	Locks all curve tables in the static and the dynamic NC memory
`CTABLOCK(,,"SRAM")`	Locks all curve tables in the static NC memory
`CTABLOCK(,,"DRAM")`	Locks all curve tables in the dynamic NC memory
`CTABUNLOCK()`	Unlocks all curve tables in the static and dynamic NC memory
`CTABUNLOCK(,,"SRAM")`	Unlocks all curve tables in the static NC memory
`CTABUNLOCK(,,"DRAM")`	Unlocks all curve tables in the dynamic NC memory

11.2.5 Curve tables: Determine table properties (CTABID, CTABISLOCK, CTABMEMTYP, CTABPERIOD)

Function

These commands can be used to poll important properties of a curve table (table number, lock state, memory location, periodicity).

Syntax

```
CTABID(<p>)
CTABID(<p>,<memory location>)
CTABISLOCK(<n>)
CTABMEMTYP(<n>)
TABPERIOD(<n>)
```

Meaning

CTABID	Returns the **table number** entered as the <p>th curve table in the specified memory. Example: CTABID(1,"SRAM") returns the number of the first curve table in the static NC memory. In this context the first curve table is the curve table with the highest table number. **Note:** If the sequence of curve tables in the memory changes between consecutive calls of CTABID, e.g. due to the deletion of curve tables with CTABDEL, CTABID(<p>,...) can return a different curve table with the same number <p>.
CTABISLOCK	Returns the **lock state** of curve table number <n>: 0 Table is not locked 1 Table is locked by CTABLOCK 2 Table is locked by active coupling 3 Table is locked by CTABLOCK and active coupling -1 Table does not exist
CTABMEMTYP	Returns the **memory location** of curve table number <n>: 0 Table in the static NC memory 1 Table in the dynamic NC memory -1 Table does not exist
CTABPERIOD	Returns the **periodicity** of curve table number <n>: 0 Table is not periodic 1 Table is periodic in the leading axis 2 Table is periodic in the leading and following axes -1 Table does not exist
<p>	Entry number in memory
<n>	Number (**ID**) of curve table
<memory location>	Specification of memory location (optional) "SRAM" **Static** NC memory "DRAM" **Dynamic** NC memory **Note:** If a value is not programmed for this parameter, the default memory location set with MD20905 $MC_CTAB_DEFAULT_MEMORY_TYPE is used.

11.2.6 Read curve table values (CTABTSV, CTABTEV, CTABTSP, CTABTEP, CTABSSV, CTABSEV, CTAB, CTABINV, CTABTMIN, CTABTMAX)

Function

The following curve table values can be read in the part program:

- Following axis and leading axis values at the start and end of a curve table
- Following axis values at the start and end of a curve segment
- Following axis value for a leading axis value
- Leading axis value for a following axis value
- Following axis minimum and maximum values
  - In the entire definition range of the curve table

    or
  - In a defined curve table interval

Syntax

```
CTABTSV(<n>,<gradient>[,<following axis>])
CTABTEV(<n>,<gradient>[,<following axis>])
CTABTSP(<n>,<gradient>[,<leading axis>])
CTABTEP(<n>,<gradient>[,<leading axis>])
CTABSSV(<master value>,<n>,<gradient>[,<following axis>])
CTABSEV(<master value>,<n>,<gradient>[,<following axis>])
CTAB(<master value>,<n>,<gradient>[,<following axis>,<leading axis>]
CTABINV(<following value>,<approximate
value>,<n>,<gradient>[,<following axis>,<leading axis>]
CTABTMIN(<n>[,<following axis>])
CTABTMAX(<n>[,<following axis>])
CTABTMIN(<n>,<a>,<b>[,<following axis>,<leading axis>])
CTABTMAX(<n>,<a>,<b>[,<following axis>,<leading axis>])
```

Meaning

`CTABTSV`:	Read following axis value at the **start** of curve table no. `<n>`
`CTABTEV`:	Read following axis value at the **end** of curve table no. `<n>`
`CTABTSP`:	Read leading axis value at the **start** of curve table no. `<n>`
`CTABTEP`:	Read leading axis value at the **end** of curve table no. `<n>`
`CTABSSV`:	Read following axis value at the **start** of the curve segment belonging to the specified leading axis value (`<master value>`)
`CTABSEV`:	Read following axis value at the **end** of the curve segment belonging to the specified leading axis value (`<master value>`)
`CTAB`:	Read following axis value for specified leading axis value (`<master value>`)
`CTABINV`:	Read leading axis value for specified following axis value (`<following value>`)

CTABTMIN:	Define following axis **minimum value**: • In the entire definition range of the curve table or • In a defined interval <a> ... <b>
CTABTMAX:	Define following axis **maximum value**: • In the entire definition range of the curve table or • In a defined interval <a> ... <b>
<n>:	Number (**ID**) of curve table
<gradient>:	The <gradient> parameter returns the **incline** of the curve table function at the calculated position.
<following axis>:	Axis whose motion is to be calculated using the curve table (optional)
<leasing axis>:	Axis providing the master values for the calculation of the following axis motion (optional)
<following value>:	Following axis value for reading the associated leading axis value for CTABINV
<leading value>:	Leading axis value: • For reading the associated following axis value with CTAB or • For the selection of the curve segment with CTABSSV/CTABSEV
<approximate value>:	The assignment of a leading axis value to a following axis value with CTABINV must not always be unique. CTABINV requires, therefore, an approximate value for the expected leading axis value as a parameter.
<a>:	**Lower** limit of the master value interval with CTABTMIN/CTABTMAX
<b>:	**Upper** limit of the master value interval with CTABTMIN/CTABTMAX **Note:** The master value interval <a> to <b> always has to be within the curve table's definition range.

Examples

Example 1:

Define following axis and leading axis values at the start and end of the curve table, along with the minimum and maximum values of the following axis in the entire definition range of the curve table.

```
Program code                                    Comment
N10 DEF REAL STARTPOS
N20 DEF REAL ENDPOS
N30 DEF REAL STARTPARA
N40 DEF REAL ENDPARA
N50 DEF REAL MINVAL
```

```
Program code                                    Comment
N60 DEF REAL MAXVAL
N70 DEF REAL GRADIENT
...
N100 CTABDEF(Y,X,1,0)                           ; Start of table definition
N110 X0 Y10                                     ; Start position 1st table segment
N120 X30 Y40                                    ; End position 1st table segment = start position 2nd
                                                table segment
N130 X60 Y5                                     ; End position 2nd table segment = ...
N140 X70 Y30
N150 X80 Y20
N160 CTABEND                                    ; End of table definition.
...
N200 STARTPOS=CTABTSV(1,GRADIENT)               ; Following axis value at start of curve table = 10
N210 ENDPOS=CTABTEV(1,GRADIENT)                 ; Following axis value at end of curve table = 20
N220 STARTPARA=CTABTSP(1,GRADIENT)              ; Master axis value at start of curve table = 0
N230 ENDPARA=CTABTEP(1,GRADIENT)                ; Master axis value at end of curve table = 80
N240 MINVAL=CTABTMIN(1)                         ; Minimum value of following axis with Y=5
N250 MAXVAL=CTABTMAX(1)                         ; Maximum value of following axis with Y=40
```

Example 2:

Determination of following axis values at the start and end of the curve segment associated with leading axis value X=30.

```
Program code                                    Comment
N10 DEF REAL STARTPOS
N20 DEF REAL ENDPOS
N30 DEF REAL GRADIENT
...
N100 CTABDEF(Y,X,1,0)                           ; Start of table definition.
N110 X0 Y0                                      ; Start position 1st table segment
N120 X20 Y10                                    ; End position 1st table segment = start position 2nd
                                                table segment
N130 X40 Y40                                    ; End position 2nd table segment = ...
N140 X60 Y10
N150 X80 Y0
N160 CTABEND                                    ; End of table definition.
...
N200 STARTPOS=CTABSSV(30.0,1,GRADIENT)          ; Start position Y in 2nd segment = 10
N210 ENDPOS=CTABSEV(30.0,1,GRADIENT)            ; End position Y in 2nd segment = 40
```

Further information

Use in synchronized actions

All commands for reading curve table values can also be used in synchronized actions (see also the chapter titled "Motion-synchronous actions").

When using the `CTABINV`, `CTABTMIN`, and `CTABTMAX` commands, make sure that:

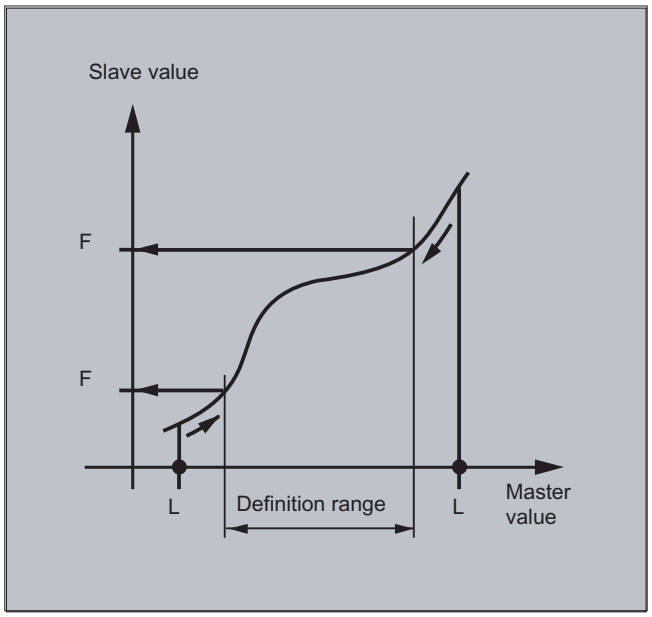
- Sufficient NC power is available at the time of execution

  or

- The number of segments in the curve table is queried prior to the call, so that the table concerned can be subdivided if necessary

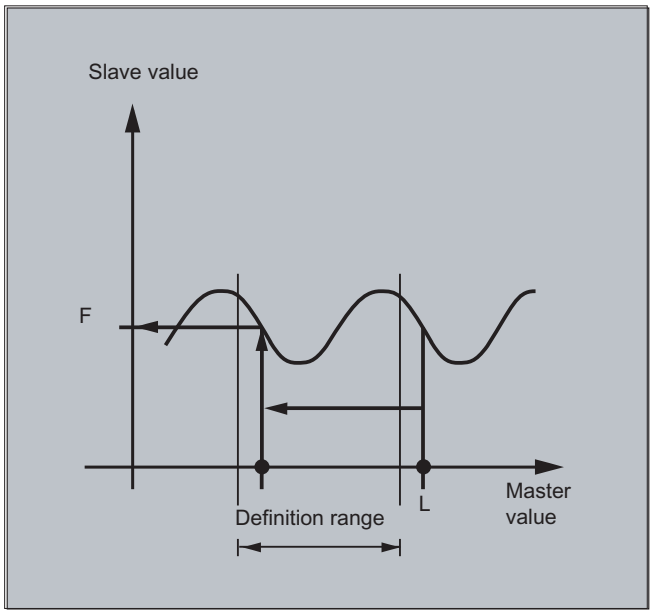
CTAB with non-periodic curve tables

If the specified `<master value>` is outside the definition range, the upper or lower limit will be output as the following value:



CTAB with periodic curve tables

If the specified <master value> is outside the definition range, the master value is evaluated modulo of the definition range and the corresponding following value is output:



Approximate value for CTABINV

The CTABINV command, therefore, requires an approximate value for the expected master value. CTABINV returns the master value that is closest to the approximate value. The approximate value can be, for example, the master value from the previous interpolation cycle.

Incline of the curve table function

The output of the incline (<gradient>) makes it possible to calculate the velocity of the leading or following axis at the corresponding position.

Specification of the leading or following axis

The optional specification of the leading and/or following axis is important if the leading and following axes are configured in different length units.

CTABSSV, CTABSEV

The CTABSSV and CTABSEV commands are **not** suitable to query programmed segments in the following cases:

- Circles or involutes are programmed.
- Chamfer or rounding with CHF/ RND is active
- Smoothing with G643 is active
- NC block compression with COMPON/COMPCURV/COMPCAD is active

11.2.7 Curve tables: Check use of resources (CTABNO, CTABNOMEM, CTABFNO, CTABSEGID, CTABSEG, CTABFSEG, CTABMSEG, CTABPOLID, CTABPOL, CTABFPOL, CTABMPOL)

Function

The programmer can use these commands to obtain up-to-date information about the use of resources for curve tables, table segments, and polynomials.

Syntax

```
CTABNO
CTABNOMEM(<memory location>)
CTABFNO(<memory location>)
CTABSEGID(<n>,<memory location>)
CTABSEG(<memory location>,<segment type>)
CTABFSEG(<memory location>,<segment type>)
CTABMSEG(<memory location>,<segment type>)
CTABPOLID(<n>)
CTABPOL(<memory location>)
CTABFPOL(<memory location>)
CTABMPOL(<memory location>)
```

Meaning

`CTABNO`	Determine total number of **defined** curve tables (in the static and the dynamic NC memory)
`CTABNOMEM`	Determine the number of **defined** curve tables in the specified `<memory location>`
`CTABFNO`	Determine the number of curve tables **remaining possible** in the specified `<memory location>`
`CTABSEGID`	Determine the number of curve segments of the specified `<segment type>` used by curve table number `<n>`
`CTABSEG`	Determine the number of curve segments of the specified `<segment type>` **used** in the specified `<memory location>`
`CTABFSEG`	Determine the number of curve segments of the specified `<segment type>` **remaining possible** in the specified `<memory location>`
`CTABMSEG`	Determine the **maximum possible** number of curve segments of the specified `<segment type>` in the specified `<memory location>`
`CTABPOLID`	Determine the number of curve polynomials used by curve table number `<n>`
`CTABPOL`	Determine the number of curve polynomials **used** in the specified `<memory location>`
`CTABFPOL`	Determine the number of curve polynomials **remaining possible** in the specified `<memory location>`
`CTABMPOL`	Determine the **maximum possible** number of curve polynomials in the specified `<memory location>`
`<n>`	Number (**ID**) of curve table

<memory location> Specification of memory location (optional)

"SRAM" **Static** NC memory

"DRAM" **Dynamic** NC memory

Note:
If a value is not programmed for this parameter, the default memory location set with MD20905 $MC_CTAB_DEFAULT_MEMORY_TYPE is used.

<segment type> Specification of segment type (optional)

"L" Linear segments

"P" Polynomial segments

Note:
If no value is programmed for this parameter, the sum of the linear and polynomial segments is output.

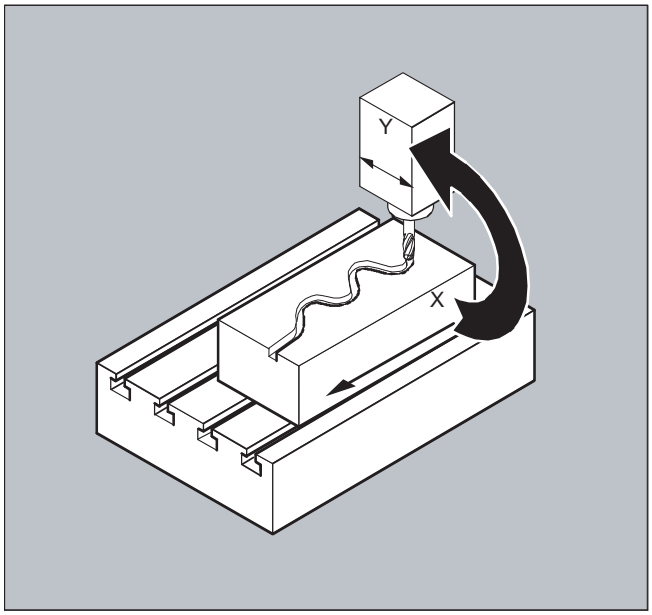
11.3 Axial master value coupling (LEADON, LEADOF)

Note

This function is not available for SINUMERIK 828D!

Function

With the axial master value coupling, a leading and a following axis are moved in synchronism. It is possible to assign the position of the following axis via a curve table or the resulting polynomial uniquely to a position of the leading axis – simulated if necessary.



The **leading axis** is the axis which supplies the input values for the curve table. The **following axis** is the axis, which takes the positions calculated by means of the curve table.

Actual value and setpoint coupling

The following can be used as the master value, i.e. as the output values for position calculation of the following axis:

- Actual values of the leading axis position: Actual value coupling
- Setpoints of the leading axis position: Setpoint value coupling

The master value coupling always applies in the basic coordinate system.

For information on the creation of curve tables, see Section "Curve tables".

Syntax

```
LEADON(<following axis>,<leading axis>,<n>)
LEADOF(<following axis>,<leading axis>)
```

or deactivation without specifying the leading axis:
```
LEADOF(<following axis>)
```

The master value coupling can be activated/deactivated both from the part program and also during motion from synchronized actions.

Meaning

`LEADON`:	Activate master value coupling
`LEADOF`:	Deactivate master value coupling
`<following axis>`:	Following axis
`<leasing axis>`:	Leading axis
`<n>`:	Curve table number
`$SA_LEAD_TYPE`:	Switching between setpoint and actual value coupling

Deactivate master value coupling, LEADOF

When you deactivate the master value coupling, the following axis becomes a normal command axis again!

Axial master value coupling and different operating states, RESET

Depending on the setting in the machine data, the master value couplings are deactivated with RESET.

Example of master value coupling from synchronous action

In a pressing plant, an ordinary mechanical coupling between a leading axis (stanchion shaft) and axis of a transfer system comprising transfer axes and auxiliary axes is to be replaced by an electronic coupling system.

It demonstrates how a mechanical transfer system is replaced by an electronic transfer system. The coupling and decoupling processes are implemented as **static synchronized actions**.

From the leading axis LV (stanchion shaft), transfer axes and auxiliary axes are controlled as following axes that are defined via curve tables.

Following axes

X feed or longitudinal axis
YL closing or transverse axis
ZL lifting axis
U roll feed, auxiliary axis
V guide head, auxiliary axis
W greasing, auxiliary axis

Actions

The actions that occur include, for example, the following synchronized actions:

- Activate coupling, `LEADON(<following axis>,<leading axis>,<curve table number>)`
- Deactivate coupling, `LEADOF(<following axis>,<leading axis>)`
- Set actual value, `PRESETON(<axis>,<value>)`
- Set marker, `$AC_MARKER[i]=<value>`
- Coupling type: real/virtual master value
- Approaching axis positions, `POS[<axis>]=<value>`

Conditions

Fast digital inputs, real-time variables `$AC_MARKER` and position comparisons are linked using the Boolean operator AND for evaluation as conditions.

Note

In the following example, line change, indentation and **bold** type are used for the sole purpose of improving readability of the program. To the controller, everything that follows a line number constitutes a single line.

Comment

```
Program code                                                    Comment
                                                                ;  Defines all static synchronized actions.
                                                                ;  ****Reset marker
N2 $AC_MARKER[0]=0 $AC_MARKER[1]=0 $AC_MARKER[2]=0 $AC_MARKER[3]=0 $AC_MARKER[4]=0 $AC_MARKER[5]=0
$AC_MARKER[6]=0 $AC_MARKER[7]=0
                                                                ;  **** E1 0=>1 transfer ON
N10 IDS=1 EVERY ($A_IN[1]==1) AND ($A_IN[16]==1) AND ($AC_MARKER[0]==0)
DO LEADON(X,LW,1) LEADON(YL,LW,2) LEADON(ZL,LW,3) $AC_MARKER[0]=1
                                                                ;  **** E1 0=>1 coupling roller feed ON
N20 IDS=11 EVERY ($A_IN[1]==1) AND ($A_IN[5]==0) AND ($AC_MARKER[5]==0)
DO LEADON(U,LW,4) PRESETON(U,0) $AC_MARKER[5]=1
                                                                ;  **** E1 0->1 coupling alignment head ON
N21 IDS=12 EVERY ($A_IN[1]==1) AND ($A_IN[5]==0) AND ($AC_MARKER[6]==0)
DO LEADON(V,LW,4) PRESETON(V,0) $AC_MARKER[6]=1
                                                                ;  **** E1 0->1 lubrication coupling ON
```

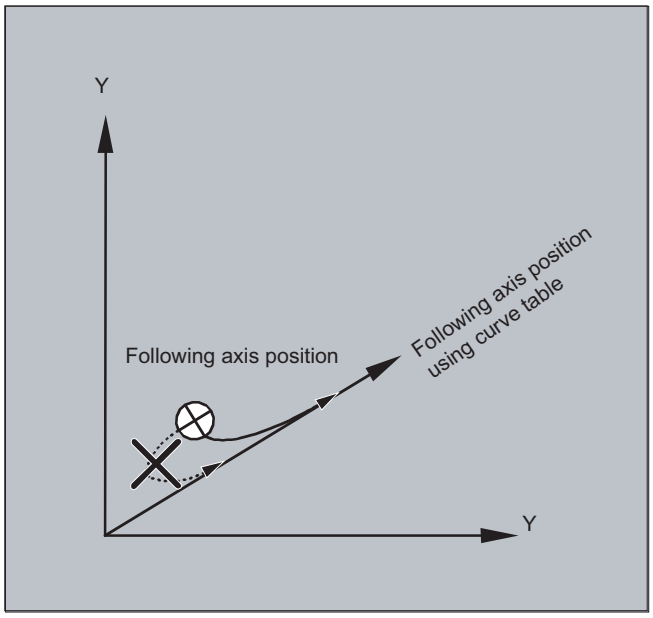
```
Program code                                                    Comment
N22 IDS=13 EVERY ($A_IN[1]==1) AND ($A_IN[5]==0) AND ($AC_MARKER[7]==0)
DO LEADON(W,LW,4) PRESETON(W,0) $AC_MARKER[7]=1
                                                    ;  **** E2 0=>1 coupling OFF
N30 IDS=3 EVERY ($A_IN[2]==1)
DO LEADOF(X,LW) LEADOF(YL,LW) LEADOF(ZL,LW) LEADOF(U,LW) LEADOF(V,LW) LEADOF(W,LW) $AC_MARKER[0]=0
$AC_MARKER[1]=0 $AC_MARKER[3]=0 $AC_MARKER[4]=0 $AC_MARKER[5]=0 $AC_MARKER[6]=0 $AC_MARKER[7]=0
....
N110 G04 F01
N120 M30
```

Description

Master value coupling requires synchronization of the leading and the following axes. This synchronization can only be achieved if the following axis is inside the tolerance range of the curve definition calculated from the curve table when the master value coupling is activated.

The tolerance range for the position of the following axis is defined via machine data `MD 37200: COUPLE_POS_POL_COARSE A_LEAD_TYPE`.

If the following axis is not yet at the correct position when the master value coupling is activated, the synchronization run is automatically initiated as soon as the position setpoint value calculated for the following axis is approximately the real following axis position. During the synchronization procedure the following axis is traversed in the direction that is defined by the setpoint speed of the following axis (calculated from master spindle and using the CTAB curve table).

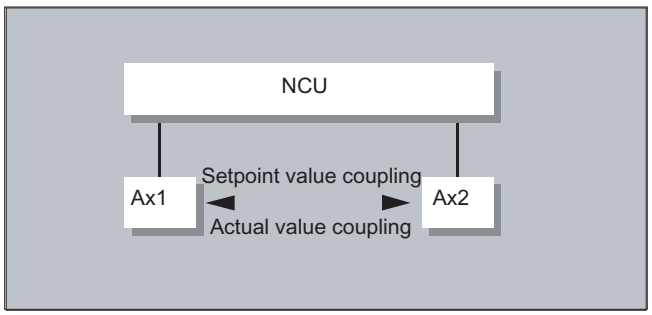


No synchronism

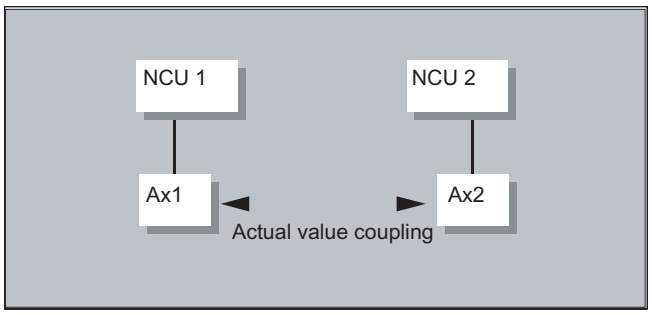
If the following axis position calculated moves away from the current following axis position when the master value coupling is activated, it is not possible to establish synchronization.

Actual value and setpoint coupling

Setpoint coupling provides better synchronization of the leading and following axis than actual value coupling and is therefore set by default.



Setpoint coupling is only possible if the leading and following axis are interpolated by the same NCU. With an external leading axis, the following axis can only be coupled to the leading axis via the actual values.



A **switchover** can be programmed via setting data $SA_LEAD_TYPE.

You must always switch between the actual-value and setpoint coupling when the following axis stops. It is only possible to resynchronize after switchover when the axis is motionless.

Application example

You cannot read the actual values without error during large machine vibrations. If you use master value coupling in press transfer, it might be necessary to switchover from actual-value coupling to setpoint coupling in the work steps with the greatest vibrations.

Master value simulation with setpoint coupling

Via machine data, you can disconnect the interpolator for the leading axis from the servo. In this way you can generate setpoints for setpoint coupling without actually moving the leading axis.

Master values generated from a setpoint link can be read from the following variables so that they can be used, for example, in synchronized actions:

- $AA_LEAD_P	Master value position
- $AA_LEAD_V	Master value velocity

Create master value

As an option, master values can be generated with other self-programmed methods. The master values generated in this way are written to and read from variables

- $AA_LEAD_SP	Master value position
- $AA_LEAD_SV	Master value velocity

Before you use these variables, the setting data $SA_LEAD_TYPE = 2 must be set.

Status of coupling

You can query the status of the coupling in the NC program with the following system variable:

```
$AA_COUP_ACT[[axis]]
```
0: No coupling active
16: Master value coupling active

Status management for synchronized actions

Switching and coupling events are managed via real-time variables:

```
$AC_MARKER[i] = n
```
managed with:
i flag number
n status value

11.4 Electronic gear (EG)

Function

The "Electronic gear" function allows you to control the movement of a **following axis** according to linear traversing block as a function of up to five **leading axes**. The relationship between each leading axis and the following axis is defined by the coupling factor.

The following axis motion part is calculated by an addition of the individual leading axis motion parts multiplied by their respective coupling factors. When an EG axis grouping is activated, it is possible to synchronize the following axes in relation to a defined position. A gear group can be:

- Defined
- Activated
- Deactivated
- Deleted

The following axis movement can be optionally derived from

- Setpoints of the leading axes, as well as
- Actual values of leading axes.

Non-linear relationships between each leading axis and the following axis can also be realized as extension using **curve tables** (see "Path traversing behavior" section). Electronic gears can be cascaded, i.e., the following axis of an electronic gear can be the leading axis for a further electronic gear.

11.4.1 Defining an electronic gear (EGDEF)

Function

An EG axis group is defined by specifying the following axis and at least one, however not more than five, leading axis, each with the relevant coupling type.

Requirement

Requirements for defining an EG axis group:

It is not permissible to define an axis coupling for the following axis (or an existing one must first be deleted with `EGDEL`).

Syntax

```
EGDEF(following axis,leading axis1,coupling type1,leading
axis2,coupling type2,...)
```

Meaning

`EGDEF`	Definition of an electronic gear
`Following axis`	Axis that is influenced by the leading axes
`Leading axis1 ,...,Leading axis5`	Axes that influence the following axis
`Coupling type1 ,...,Coupling type5`	Coupling type The coupling type does not need to be the same for all leading axes and must be programmed separately for each individual master.

Value:	Meaning:
0	The following axis is influenced by the **actual value** of the corresponding leading axis.
1	The following axis is influenced by the **setpoint** of the corresponding leading axis.

Note

The coupling factors are preset to zero when the EG axis grouping is defined.

Note

EGDEF triggers preprocessing stop. The gearbox definition with EGDEF should also be used unaltered if, for systems, one or more leading axes affect the following axis via a **curve table**.

Example

```
Program code                    Comment
EGDEF(C,B,1,Z,1,Y,1)            ; Definition of an EG axis group. Leading axes B, Z, Y
                                  influence the following axis C via the setpoint.
```

11.4.2 Switch-in the electronic gearbox (EGON, EGONSYN, EGONSYNE)

Function

There are 3 ways to switch-in an EG axis group.

Syntax

Variant 1:

The EG axis group is selectively switched-in without synchronization with:

```
EGON(FA,"block change mode",LA1,Z1,N1,LA2,Z2,N2,...,LA5,Z5,N5)
```

Variant 2:

The EG axis group is selectively activated with synchronization with:

```
EGONSYN(FA,"block change mode",SynPosFA,[,LAi,SynPosLAi,Zi,Ni])
```

Variant 3:

The EG axis group is selectively switched-in with synchronization and the approach mode specified with:

```
EGONSYNE(FA,"block change mode",SynPosFA,approach
mode[,LAi,SynPosLAi,Zi,Ni])
```

Meaning

Variant 1:

`FA`	Following axis
`Block change mode`	The following modes can be used:
	`"NOC"` Block change takes place immediately
	`"FINE"` Block change is performed in "Fine synchronism"
	`"COARSE"` Block change is performed in "Coarse synchronism"
	`"IPOSTOP"` Block change is performed for setpoint-based synchronism
`LA1, ... LA5`	Leading axes
`Z1, ... Z5`	Numerator for coupling factor i
`N1, ... N5`	Denominator for coupling factor i
	Coupling factor i = numerator i/denominator i

Only the leading axes previously specified with the `EGDEF` command may be programmed in the activation line. At least one leading axis must be programmed.

Variant 2:

`FA`	Following axis
`Block change mode`	The following modes can be used:
	`"NOC"` Block change takes place immediately
	`"FINE"` Block change is performed in "Fine synchronism"
	`"COARSE"` Block change is performed in "Coarse synchronism"
	`"IPOSTOP"` Block change is performed for setpoint-based synchronism
`[,LAi,SynPosLAi,Zi,Ni]`	(do not write the square brackets)
	Min. 1, max. 5 sequences of:
`LA1, ... LA5`	Leading axes
`SynPosLAi`	Synchronized position for i-th leading axis
`Z1, ... Z5`	Numerator for coupling factor i
`N1, ... N5`	Denominator for coupling factor i
	Coupling factor i = numerator i/denominator i

Only leading axes previously specified with the `EGDEF` command may be programmed in the activation line. Through the programmed "Synchronized positions" for the following axis (`SynPosFA`) and for the leading axes (`SynPosLA`), positions are defined for which the axis grouping is interpreted as *synchronous*. If the electronic gear is not in the synchronized state when the grouping is switched on, the following axis traverses to its defined synchronized position.

Variant 3:

The parameters correspond to those of variant 2 plus:

`Approach mode` The following modes can be used:

`"NTGT"`	Approach next tooth gap time-optimized
`"NTGP"`	Approach next tooth gap path-optimized
`"ACN"`	Traverse rotary axis in negative direction absolute
`"ACP"`	Traverse rotary axis in positive direction absolute
`"DCT"`	Time-optimized for programmed synchronous position
`"DCP"`	Distance-optimized to the programmed synchronous position

Variant 3 only affects modulo following axes that are coupled to modulo leading axes. Time optimization takes account of velocity limits of the following axis.

Further Information

Description of the switch-in versions

Version 1:

The positions of the leading axes and following axis at the instant the grouping is switched on are stored as "Synchronized positions". The "Synchronized positions" can be read with the system variable `$AA_EG_SYN`.

Version 2:

If modulo axes are contained in the coupling group, their position values are modulus-reduced. This ensures that the next possible synchronized position is approached (so-called *relative synchronization*: e.g. the next tooth gap). The synchronized position is only approached if "Enable following axis override" interface signal DB(30 + axis number), DBX 26 bit 4 is issued for the following axis. If it is not issued, the program stops at the EGONSYN block and self-clearing alarm 16771 is output until the above mentioned signal is set.

Version 3:

The tooth distance (deg.) is calculated like this: 360 * Zi/Ni. If the following axis is stopped at the time of calling, path optimization returns responds identically to time optimization.

If the following axis is already in motion, `NTGP` will synchronize at the next tooth gap irrespective of the current velocity of the following axis. If the following axis is already in motion, `NTGT` will synchronize at the next tooth gap depending on the current velocity of the following axis. The axis is also decelerated, if necessary.

Curve tables

If a **curve table** is used for one of the leading axes:

Ni The denominator of the coupling factor for linear coupling must be set to 0. (Denominator 0 would be illegal for linear couplings.) Denominator zero tells the control that

Zi is the number of the curve table to use. The curve table with the specified number must already be defined at POWER ON.

LAi The leading axis specified corresponds to the one specified for coupling via coupling factor (linear coupling).

For more information about using curve tables and cascading and synchronizing electronic gears, please refer to:
References:
Function Manual Special Functions; Coupled Axes and ESR (M3), "Coupled Motion and Leading Value Coupling".

Response of the Electronic gear at Power ON, RESET, mode change, block search

- **No** coupling is active after POWER ON.
- The status of active couplings is not affected by RESET or operating mode switchover.
- During block searches, commands for switching, deleting and defining the electronic gear are not executed or collected, but skipped.

System variables of the electronic gear

By means of the electronic gear's system variables, the part program can determine the current states of an EG axis grouping and react to them if required.

The system variables of the electronic gearbox are designated as follows:

$AA_EG_ ...

or

$VA_EG_ ...

References:
System Variables Manual

11.4.3 Switching-in the electronic gearbox (EGOFS, EGOFC)

Function

There are 3 different ways to switch-out an active EG axis group.

Programming

Variant 1:

Syntax	Meaning
`EGOFS(following axis)`	The electronic gear is deactivated. The following axis is braked to a standstill. This call triggers a preprocessing stop.

Variant 2:

Syntax	Meaning
`EGOFS(following axis,leading axis1,…,leading axis5)`	This command parameter setting made it possible to **selectively** remove the influence of the individual leading axes on the following axis' motion.

At least one leading axis must be specified. The influence of the specified leading axes on the slave is selectively inhibited. This call triggers a preprocessing stop. If the call still includes active leading axes, then the slave continues to operate under their influence. If the influence of all leading axes is excluded by this method, then the following axis is braked to a standstill.

Variant 3:

Syntax	Meaning
`EGOFC(following spindle1)`	The electronic gear is deactivated. The following spindle continues to traverse at the speed/velocity that applied at the instant of deactivation. This call triggers a preprocessing stop.

Note

This variant is only permitted for spindles.

11.4.4 Deleting the definition of an electronic gear (EGDEL)

Function

An EG axis group must be switched-out before its definition can be deleted.

Programming

Syntax	Meaning
`EGDEL(following axis)`	The coupling definition of the axis group is deleted. Additional axis groups can be defined by means of `EGDEF` until the maximum number of simultaneously activated axis groups is reached. This call triggers a preprocessing stop.

11.4.5 Rotational feedrate (G95) / electronic gear (FPR)

Function

The `FPR` command can be used to specify the following axis of an electronic gear as the axis, which determines the revolutional feedrate. Please note the following with respect to this command:

- The feedrate is determined by the setpoint velocity of the following axis of the electronic gear.
- The setpoint velocity is calculated from the speeds of the leading spindles and modulo axes (which are not path axes) and from their associated coupling factors.
- Speed parts of linear or non-modulo leading axes and overlaid movement of the following axis are not taken into account.

11.5 Synchronous spindle

Function

Synchronous operation involves a following spindle (FS) and a leading spindle (LS), referred to as the **synchronous spindle pair**. The following spindle imitates the movements of the leading spindle when a coupling is active (synchronous operation) in accordance with the defined functional interrelationship.

The synchronous spindle pairs for each machine can be assigned a fixed configuration by means of channel-specific machine data or defined for specific applications via the CNC part program. Up to two synchronized spindle pairs can be operated simultaneously on each NC channel.

Refer to the part program for the following coupling actions

- Defined or changed
- Activated
- Deactivated
- Deleted

In addition, depending on the software status

- It is possible to wait for the synchronism conditions
- The block change method can be changed
- Either the setpoint coupling or actual value coupling type is selected or the angular offset between master and following spindle specified
- When activating the coupling, previous programming of the following axis is transferred
- Either a measured or a known synchronism variance is corrected

11.5.1 Synchronous spindle: Programming (COUPDEF, COUPDEL, COUPON, COUPONC, COUPOF, COUPOFS, COUPRES, WAITC)

Function

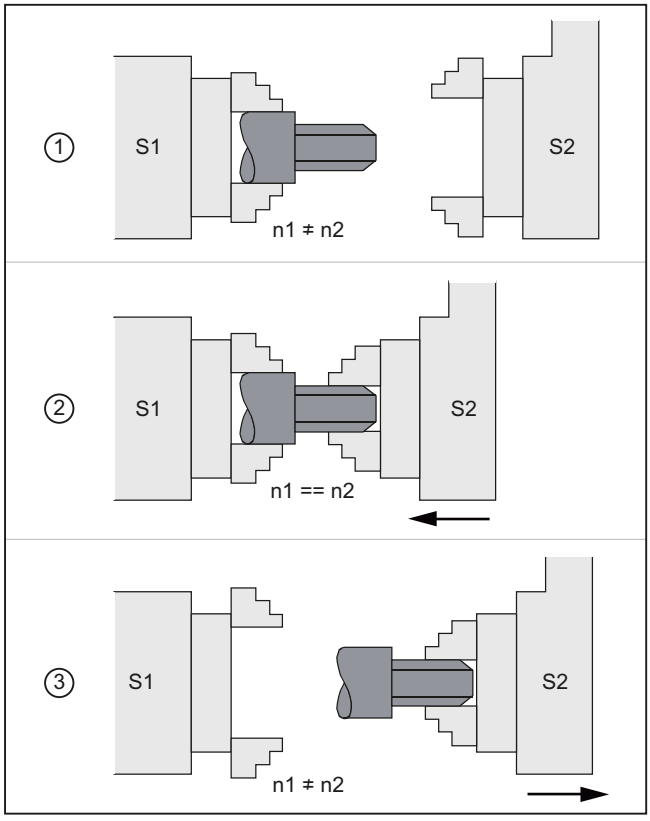
The "Synchronous spindle" enables the speed-synchronous traversing of the following spindle (FS) and leading spindle (LS) with a programmable transformation ratio.

The function supports the following modes:

- Speed synchronism ($n_{FS} = n_{LS}$)
- Position synchronism ($\varphi_{FS} = \varphi_{LS}$)
- Position synchronism with angular offset ($\varphi_{FS} = \varphi_{LS} + \Delta\varphi$)

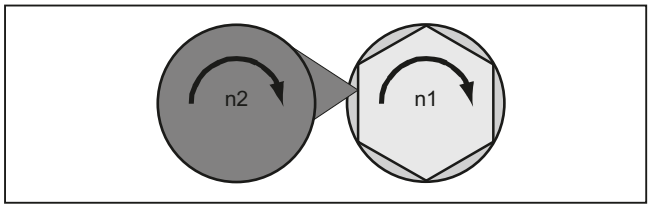
Application examples:

- Flying workpiece transfer, e.g. to machine the rear side, transformation ratio: 1:1



① Synchronize the speed
② Transfer the workpiece
③ Machine the rear side

- Multi-edge machining (polygonal turning), speed synchronism, transformation ratio: n_1:n_2



Syntax

```
COUPDEF(<FS>,<LS>,<ZFS>,<NLS>,<block change>,<coupling type>)
COUPON(<FS>,<LS>,<POSFS>)
COUPONC(<FS>,<LS>)
COUPOF(<FS>,<LS>,<POSFS>,<POSLS>)
COUPOFS(<FS>,<LS>)
COUPOFS(<FS>,<LS>,<POSFS>)
COUPRES(<FS>,<LS>)
COUPDEL(<FS>,<LS>)
WAITC(<FS>,<block change>,<LS>,<block change>)
```

Note

Abbreviated notation

The COUPOF, COUPOFS, COUPRES, and COUPDEL statements support abbreviated notation without specification of the leading spindle.

Meaning

COUPDEF:	Define/change coupling on user-specific basis
COUPON:	Activate coupling. The following spindle synchronizes to the leading spindle based on the actual speed
COUPONC:	Coupling when activating with previous programming of M3 S... or M4 S.... A difference in speed for the following spindle is transferred immediately.
COUPOF:	Deactivate coupling. • With immediate block change: COUPOF(<S2>,<S1>) • Block change only after <POSFS> or <POSLS> deactivation position(s) has (have) been crossed: COUPOF(<S2>,<S1>,<POSFS>) COUPOF(<S2>,<S1>,<POSFS>,<POSLS>)
COUPOFS:	Deactivating a coupling with stop of following spindle. Block change as quickly as possible with immediate block change: COUPOFS(<S2>,<S1>) Block change only after passing the switch-off position: COUPOFS(<S2>,<S1>,<POSFS>)
COUPRES:	Reset coupling parameters to configured MD and SD
COUPDEL:	Delete user-defined coupling
WAITC:	Wait for synchronized run condition (NOC are increased to IPO during block changes)
<FS>:	Designation of following spindle

Optional parameters:

<LS>:	Designation of main spindle Specification with spindle number: e.g. S2, S1
<ZFS>, <NLS>:	Transformation ratio between FS and LS. <ZFS>/<NLS> = numerator/denominator Default: <ZFS>/<NLS> = 1.0 ; specification of denominator optional

<block change>:	Block change behavior	
	The block change is:	
	"NOC"	Immediately
	"FINE"	On reaching "Synchronism fine"
	"COARSE"	On reaching "Synchronism coarse"
	"IPOSTOP"	On reaching IPOSTOP; in other words, after setpoint-based synchronism (default)
	The block change behavior is effective modally.	
<coupling type>:	Coupling type: Coupling between FS and LS	
	"DV"	Setpoint linkage (default)
	"AV"	Actual value coupling
	"VV"	Speed coupling
	The coupling type is modal.	
<POSFS>:	Angle offset between leading and following spindles	
	Range of values:	0°… 359.999°
<POSFS>,<POSLS>:	Switch-off positions of the following and leading spindles	
	"The block change is enabled once POS_{FS}, POS_{LS} has been passed"	
	Range of values:	0°… 359.999°

Examples

Working with leading and following spindles

Program code	Comment
	Leading spindle = master spindle = spindle 1
	Following spindle = spindle 2
N05 M3 S3000 M2=4 S2=500	Leading spindle rotates at 3000 rpm, following spindle at 500 rpm.
N10 COUPDEF(S2,S1,1,1,"NOC","Dv")	Definition of the coupling (can also be configured).
...	
N70 SPCON	Bring leading spindle into closed-loop position control (setpoint coupling).
N75 SPCON(2)	Bring following spindle into closed-loop position control.
N80 COUPON(S2,S1,45)	On-the-fly coupling to offset position = 45 degrees.
...	
N200 FA[S2]=100	Positioning speed = 100 degrees/min
N205 SPOS[2]=IC(-90)	Traverse with 90 degree overlay in negative direction.
N210 WAITC(S2,"Fine")	Wait for "fine" synchronism.
N212 G1 X... Y... F...	Machining
...	

Program code	Comment
N215 SPOS[2]=IC(180)	Traverse with 180 degree overlay in the positive direction.
N220 G4 S50	Dwell time = 50 revolutions of the master spindle
N225 FA[S2]=0	Activate configured velocity (MD).
N230 SPOS[2]=IC(-7200)	20 revolutions. Move with configured velocity in the negative direction.
...	
N350 COUPOF(S2,S1)	Couple-out on-the-fly, S=S2=3000
N355 SPOSA[2]=0	Stop FS at zero degrees.
N360 G0 X0 Y0	
N365 WAITS(2)	Wait for spindle 2.
N370 M5	Stop FS.
N375 M30	

Programming a difference in speed

Program code	Comment
	Leading spindle = master spindle = spindle 1
	Following spindle = spindle 2
N01 M3 S500	Leading spindle rotates at 500 rpm.
N02 M2=3 S2=300	Following spindle rotates at 300 rpm.
...	
N10 G4 F1	Dwell time of master spindle.
N15 COUPDEF (S2,S1,-1)	Coupling factor with ratio -1:1
N20 COUPON(S2,S1)	Activate coupling. The speed of the following spindle results from the speed of the leading spindle and coupling factor.
...	
N26 M2=3 S2=100	Programming a difference in speed.

Examples of transfer of a movement for difference in speed

1. Activate coupling during previous programming of following spindle with COUPON

Program code	Comment
	Leading spindle = master spindle = spindle 1
	Following spindle = spindle 2
N05 M3 S100 M2=3 S2=200	Leading spindle rotates at 100 rpm, following spindle at 200 rpm.
N10 G4 F5	Dwell time = 5 seconds of master spindle
N15 COUPDEF(S2,S1,1)	Transformation ratio of FS to LS is 1.0 (default).
N20 COUPON(S2,S1)	On-the-fly coupling to the leading spindle.
N10 G4 F5	Following spindle rotates at 100 rpm.

2. Activate coupling during previous programming of following spindle with COUPONC

Program code	Comment
	Leading spindle = master spindle = spindle 1
	Following spindle = spindle 2
N05 M3 S100 M2=3 S2=200	Leading spindle rotates at 100 rpm, following spindle at 200 rpm.
N10 G4 F5	Dwell time = 5 seconds of master spindle
N15 COUPDEF(S2,S1,1)	Transformation ratio of FS to LS is 1.0 (default).
N20 COUPONC(S2,S1)	On-the-fly coupling to leading spindle and transfer previous speed to S2.
N10 G4 F5	S2 rotates at 100 rpm + 200 rpm = 300 rpm

3. Activate coupling with following spindle stationary with COUPON

Program code	Comment
	Leading spindle = master spindle = spindle 1
	Following spindle = spindle 2
N05 SPOS=10 SPOS[2]=20	Following spindle S2 in positioning mode.
N15 COUPDEF(S2,S1,1)	Transformation ratio of FS to LS is 1.0 (default).
N20 COUPON(S2,S1)	On-the-fly coupling to the leading spindle.
N10 G4 F1	Coupling is closed, S2 stops at 20 degrees.

4. Activate coupling with following spindle stationary with COUPONC

Note

Positioning or axis mode

If the following spindle is in positioning or axis mode before coupling, then the following spindle behaves the same for COUPON(<FS>,<LS>) and COUPONC(<FS>,<LS>).

Note

Leading spindle and axis operation

If, prior to the coupling being defined, the leading spindle is in axis operation, the velocity limit value from machine data

MD32000 $MA_MAX_AX_VELO (maximum axis velocity) will still apply even after the coupling is activated.

To avoid this behavior, the axis must be switched to spindle mode (M3 S... or M4 S...) prior to the coupling being defined.

Further information

Configured coupling

For the configured coupling, the LS and FS are defined via machine data. The configured spindles cannot be changed in the part program. The coupling can be parameterized in the part program using COUPDEF (on condition that no write protection is valid).

User-defined coupling

COUPDEF can be used to redefine or change a coupling in the part program. If a coupling is already active, it has to be deleted first with COUPDEL before a new coupling is defined.

A coupling is defined in its entirety by:

```
COUPDEF(<FS>,<LS>,<TFS>,<TLS>, block change behavior, coupling type)
```

Following spindle (FS) and leading spindle (LS)

The coupling is uniquely defined using the axis names for the FS and LS. The axis names have to be programmed with every COUPDEF statement. The other coupling parameters are modal and only have to be programmed if they change.

Example:

```
COUPDEF(S2,S1)
```

Transformation ratio

The transformation ratio is defined as the speed ration between FS and LS:

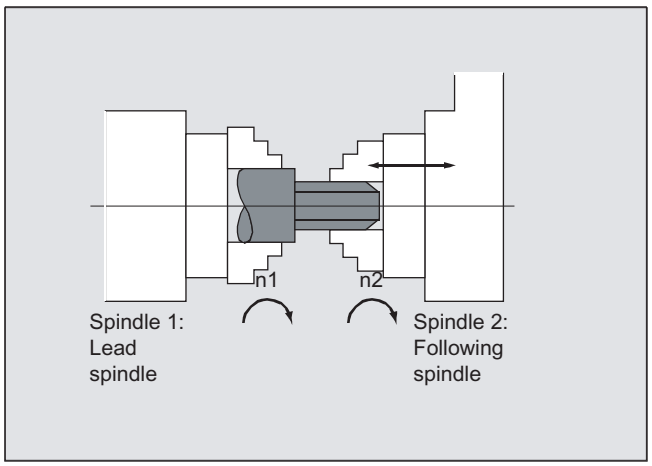
Following spindle / leading spindle = numerator/denominator

The numerator must be programmed. The denominator must not be programmed. The default value 1.0 is then set for the denominator.

Example:

Following spindle S2 and leading spindle S1, transformation ratio = 1/1

```
COUPDEF(S2, S1, 1.0)
```



Note

The transformation ratio can also be changed on-the-fly (when the coupling is active and the spindles are rotating).

Block change behavior NOC, FINE, COARSE, IPOSTOP

The following abbreviated notation can be used when programming the block change behavior:

- `"NO"`: Immediately (default)
- `"FI"`: On reaching "Synchronism fine"
- `"CO"`: On reaching "Synchronism coarse"
- `"IP"`: On reaching IPOSTOP; i.e. after setpoint-based synchronism

Type of coupling

Note

The coupling type may only be changed when the coupling is deactivated.

Activate synchronous mode COUPON, <POSFS>

- Activation of coupling with any angular offset between LS and FS:
  - `COUPON(S2,S1)`
  - `COUPON(S2)`
- Activation of coupling with angular offset <`POSFS`>

  `<POSFS>` refers to the 0° position of the leading spindle in the positive direction of rotation `<POSFS>` value range: 0°… 359.999°
  - `COUPON(S2,S1,30)`

Note

The angular offset can also be changed when the coupling is active.

Position the following spindle

Even with activated synchronous spindle coupling, the FS can be positioned in the range ±180° independently of the LS.

- Spindle positioning of the FS with `SPOS`

  Example: `SPOS[2]=IC(-90)`

  Further information on `SPOS` can be found in:
  References:
  Programming Manual, Fundamentals

Differential speed

A speed difference results in speed control mode and active synchronous spindle coupling through signed overlay of an FS speed because of LS movement and an FS speed because of spindle programming:

- Synchronous spindle coupling with COUPONC
- S<FS>=<speed> [M<FS>=<direction of rotation>]

Note

Supplementary conditions

- Speed S... must also be reprogrammed with direction of rotation M3/M4.
- Overlay of a spindle speed (M<direction of rotation> S<FS>) through the LS movement with synchronous spindle coupling COUPONC only becomes effective if the overlay has been enabled.
- The dynamic responses of the leading spindle have to be restricted to such an extent that when overlaying is applied to the following spindle, its dynamics limit values are not exceeded.

For more information about the speed difference, see:
References:
Function Manual, Extended Functions; Synchronous Spindle (S3)

Velocity, acceleration: FA, ACC, OVRA, VELOLIMA

Axial velocity and acceleration of a following spindle can be programmed with:

- FA[SPI(S<n>)] or FA[S<n>] (axial velocity)
- ACC[SPI(S<n>)] or ACC[S<n>] (axial acceleration)
- OVRA[SPI(S<n>)] and OVRA[S<n>] (axial override)
- VELOLIMA[SPI(S<n>)] and VELOLIMA[S<n>] (increase and reduction of axial velocity respectively)

When <n> = 1, 2, 3, ... (spindle numbers of the following spindles)

References:
Programming Manual, Fundamentals

Note

A reduction or increase of the maximum axial jerk has no effect with spindles.

Further information about the axial dynamic response is provided in:
References:
Function Manual, Extended Functions; Rotary Axes (R2)

Programmable block change behavior WAITC

WAITC can be used to define block change behavior, for example after a change to coupling parameters or positioning actions, with a variety of synchronism conditions (coarse, fine, IPOSTOP). If no synchronism conditions are specified, the block change behavior specified in the COUPDEF definition will apply.

Examples

- Wait for synchronism condition FINE to be fulfilled for following spindle S2 and COARSE to be fulfilled for following spindle S4: WAITC(S2,"FINE",S4,"COARSE")
- Wait for synchronism condition according to COUPDEF to be fulfilled: WAITC( )

Deactivate coupling COUPOF

COUPOF can be used to define the turn-off behavior of the coupling:

- Deactivation of coupling with immediate block change:
  - COUPOF(S2,S1) (with specification of leading spindle)
  - COUPOF(S2) (without specification of leading spindle)
- Deactivation of coupling after switch-off positions have been crossed. The block change takes place after the switch-off positions have been crossed.
  - COUPOF(S2,S1,150) (switch-off position FS: 150°)
  - COUPOF(S2,S1,150,30) (switch-off position FS: 150°, LS: 30°)

Deactivate coupling with following spindle stop COUPOFS

COUPOFS can be used to define the turn-off behavior of the coupling with following spindle stop:

- Deactivation of coupling with following spindle stop and immediate block change:
  - COUPOFS(S2,S1) (with specification of leading spindle)
  - COUPOFS(S2) (without specification of leading spindle)
- Deactivation of coupling after switch-off positions have been crossed with following spindle stop. The block change takes place after the switch-off positions have been crossed.
  - COUPOFS(S2,S1,150) (switch-off position FS: 150°)

Delete couplings COUPDEL

COUPDEL deletes the coupling:

- COUPDEL(S2,S1) (with specification of leading spindle)
- COUPDEL(S2) (without specification of leading spindle)

Reset coupling parameters, COUPRES

COUPRES activates the coupling values parameterized in the machine and setting data:

- COUPRES(S2,S1) (with specification of leading spindle)
- COUPRES(S2) (without specification of leading spindle)

System variables

- Current coupling status of following spindle

  The current coupling status of a following spindle can be read bit-coded via:

  ```
  <value> = $AA_COUP_ACT[<FS>]
  ```

Bit	<value>	Meaning
-	0	No coupling active
2	4	Synchronous spindle coupling active

Note

- All other values refer to axis mode
- If the spindle is a following spindle or several couplings, then the value of the coupling state of all couplings is returned as a total state.

- Current angular offset

  The current angular offset of the following spindle to the leading spindle can be read via:

  – `$AA_COUP_OFFS[<FS>]` (angular offset on the setpoint side)

  – `$VA_COUP_OFFS[<FS>]` (angular offset on the actual value side)

  Application example

  Correction of the angular offset difference in the NC program after cancelling the follow-up mode:

  Angular offset difference = programmed angular offset - system variable

References

Detailed information on the system variables can be found in:

List Manual, System Variables

11.6 Generic coupling (CP...)

Function

"Generic Coupling" is a general coupling function, combining all coupling characteristics of existing coupling types (coupled motion, master value coupling, electronic gearbox and synchronous spindle).

The function allows flexible programming:

- Users can select the coupling properties required for their applications (building block principle).
- Each coupling property can be programmed individually.
- The coupling properties of a defined coupling (e.g. coupling factor) can be changed.

- Later use of additional coupling properties is possible.
- The coordinate reference system of the following axis (base coordinate system or machine coordinate system) is programmable.
- Certain coupling properties can also be programmed with synchronous actions.

  References: Synchronized Actions Function Manual

Note

Previous coupling calls for coupled motion (TRAIL*), Master value coupling (LEAD*), Electronic Gearbox (EG*) and Synchronous spindle (COUP*) are supported via adaptive cycles.

Overview of all keywords and coupling characteristics

The following table gives an overview of all keywords of the generic coupling and the programmable coupling characteristics:

Keyword	Coupling characteristics / meaning	Syntax
CPDEF	Creating a coupling module	CPDEF=(<FAx>)
CPDEL	Deletion of a coupling module	CPDEL=(<FAx>)
CPLA	Definition of a leading axis	CPLA[<FAx>]=(<LAx>)
CPLDEF	Definition of a leading axis and creation of a coupling module (also possible with CPDEF + CPLA)	CPLDEF[<FAx>]=(<LAx>) or CPDEF=(<FAx>) CPLA[<FAx>]=(<LAx>)
CPLDEL	Deleting a leading axis of a coupling module (also possible with CPDEF + CPLA)	CPLDEL[<FAx>]=(<LAx>) or CPDEL=(<FAx>) CPLA[<FAx>]=(<LAx>)
CPON	Switching on a coupling module	CPON=(<FAx>)
CPOF	Switching off a coupling module	CPOF=(<FAx>)
CPLON	Switching on a leading axis of a coupling module	CPLON[<FAx>]=<LAx>
CPLOF	Switching off a leading axis of a coupling module	CPLOF[<FAx>]=<LAx>
CPLNUM	Numerator of the coupling factor	CPLNUM[FAx,LAx]=<value>
CPLDEN	Denominator of the coupling factor	CPLDEN[FAx,LAx]=<value>
CPLCTID	Number of the curve table	CPLCTID[FAx,LAx]=<value>

Keyword	Coupling characteristics / meaning	Syntax		
CPLSETVAL	Coupling reference	CPLSETVAL[FAx,LAx]="<coupling reference>"		
		"<coupling reference>":	"CMDPOS"	Setpoint value coupling
			"CMDVEL"	Speed coupling
			"ACTPOS"	Actual value coupling
CPFRS	Coordinate reference system	CPFRS[FAx]="<coordinate reference>"		
		"<coordinate reference>":	"BCS"	Basic Coordinate System
			"MCS"	Machine Coordinate System
CPBC	Block change criterion	CPBC[FAx]="<block change criterion>"		
		"<block change criterion>":	"NOC"	Block change is performed irrespective of the coupling status.
			"IPOSTOP"	Block change is performed with setpoint synchronism.
			"COARSE"	Block change is performed with actual value synchronism “coarse”.
			"FINE"	Block change is performed with actual value synchronism "fine".
CPFPOS + CPON	Synchronized position of the following axis when switching on	CPON=FAx CPFPOS[FAx]=<value>		
CPLPOS + CPON	Synchronized position of the leading axis when switching on	CPLPOS[FAx,LAx]=<value>		
CPFMSON	Synchronization mode	CPFMSON[FAx]="<synchronization mode>"		
		"<synchronization mode>":	"CFAST"	The coupling is closed time-optimized.
			"CCOARSE"	The coupling is only closed when the following axis position, required according to the coupling rule, is in the range of the current following axis position.
			"NTGT"	The next tooth gap is approached time-optimized.
			"NTGP"	The next tooth gap is approached path-optimized.
			"NRGT"	The next segment is approached in a time-optimized manner, in accordance with the ratio of the number of gears to the number of teeth.

Keyword	Coupling characteristics / meaning	Syntax		
			"NRGP"	The next segment is approached in a path-optimized manner, in accordance with the ratio of the number of gears to the number of teeth.
			"ACN"	For rotary axes only! The rotary axis traverses to the synchronized position in the negative axis direction. Synchronization is realized immediately.
			"ACP"	For rotary axes only! The rotary axis traverses to the synchronized position in the positive axis direction. Synchronization is realized immediately.
			"DCT"	For rotary axes only! The rotary axis traverses to the programmed synchronized position time-optimized. Synchronization is realized immediately.
			"DCP"	For rotary axes only! The rotary axis traverses to the programmed synchronized position path-optimized. Synchronization is realized immediately.
CPFMON	Behavior of the following axis when switching on	CPFMON[FAx]= "<switch-on behavior>"		
		"<switch-on behavior>":	"STOP"	For spindles only! An active motion of the following spindle is stopped before switch-on.
			"CONT"	For spindles and main traverse axes only! The current motion of the following axis/spindle is taken over into the coupling as start motion.
			"ADD"	For spindles only! The motion components of the coupling operate in addition to the currently overlaid motion, i.e. the current motion of the following axis/spindle is retained as overlaid motion.

Keyword	Coupling characteristics / meaning	Syntax		
CPFMOF	Behavior of the following axis at complete switch-off	CPFMOF[FAx]="<switch-off behavior>"		
		"<switch-off behavior>":	"STOP"	Stop of a following axis/spindle. An active overlaid motion is also braked to standstill. The coupling is then opened
			"CONT"	For spindles and main traverse axes only! The following spindle continues to traverse at the speed/velocity that applied at the instant of deactivation.
CPFPOS + CPOF	Switch-off position of the following axis when switching off	CPOF=(FAx) CPFPOS[FAx]=<value>		
CPMRESET	Coupling behavior for RESET	CPMRESET[FAx]="<Reset behavior>"		
		"<reset behavior>":	"NONE"	The current state of the coupling is retained.
			"ON"	When the appropriate coupling module is created, the coupling is switched on. All defined leading axis relationships are activated. This is also performed when all or parts of these leading axis relationships are active, i.e. resynchronization is performed even with a completely activated coupling.
			"OF"	An active overlaid motion is also braked to standstill. The coupling is then deactivated. When the relevant coupling module was created without an explicit definition (CPDEF), the coupling module is deleted. Otherwise it is retained, i.e. it can still be used.

Keyword	Coupling characteristics / meaning	Syntax		
			"OFC"	Possible only in spindles! The following spindle continues to traverse at the speed/velocity that applied at the instant of deactivation. The coupling is switched off. When the relevant coupling module was created without an explicit definition (CPDEF), the coupling module is deleted. Otherwise it is retained, i.e. it can still be used.
			"DEL"	An active overlaid motion is also braked to standstill. The coupling is then deactivated and then deleted.
			"DELC"	Possible only in spindles! The following spindle continues to traverse at the speed/velocity that applied at the instant of deactivation. The coupling is deactivated and then deleted.
CPMSTART	Coupling behavior at part program start	CPMSTART[FAx]="<start behavior>"		
		"<start behavior>":	"NONE"	The current state of the coupling is retained.
			"ON"	Coupling switched-on. All defined leading axis relationships are activated. This is also performed when all or parts of these leading axis relationships are active, i.e. resynchronization is performed even with a completely activated coupling.
			"OF"	The coupling is switched off. When the relevant coupling module was created without an explicit definition (CPDEF), the coupling module is deleted. Otherwise it is retained, i.e. it can still be used.
			"DEL"	The coupling is deactivated and then deleted.

Keyword	Coupling characteristics / meaning	Syntax		
CPMPRT	Coupling response at part program start under search run via program test	CPMPRT[FAx]="<start behavior>"		
		"<start behavior>":	see CPMSTART	
CPLINTR	Offset value of the input value of a leading axis	CPLINTR[FAx,LAx]=<value>		
CPLINSC	Scaling factor of the input value of a leading axis	CPLINSC[FAx,LAx]=<value>		
CPLOUTTR	Offset value for the output value of a coupling	CPLOUTTR[FAx,LAx]=<value>		
CPLOUTSC	Scaling factor for the output value of a coupling	CPLOUTSC[FAx,LAx]=<value>		
CPSYNCOP	Threshold value of position synchronism "Coarse"	CPSYNCOP[FAx]=<value>		
CPSYNFIP	Threshold value of position synchronism "Fine"	CPSYNFIP[FAx]=<value>		
CPSYNCOP2	Second threshold value for the "Coarse" position synchronism	CPSYNCOP2[FAx]=<value>		
CPSYNFIP2	Second threshold value for the "Fine" position synchronism	CPSYNFIP2[FAx]=<value>		
CPSYNCOV	Threshold value of velocity synchronism "Coarse"	CPSYNCOV[FAx]=<value>		
CPSYNFIV	Threshold value of velocity synchronism "Fine"	CPSYNFIV[FAx]=<value>		
CPMBRAKE	Response of the following axis to certain stop signals and stop commands	CPMBRAKE[FAx]=<bit-coded value>		
CPMVDI	Response of the following axis to certain NC/PLC interface signals	CPMVDI[FAx]=<bit-coded value>		
CPMALARM	Suppression of special coupling-related alarm outputs	CPMALARM[FAx]=<bit-coded value>		
CPSETTYPE	Coupling type	CPSETTYPE[FAx]="<coupling type>"		
		"<coupling type>":	"CP"	Freely programmable
			"TRAIL"	Coupling type "Coupled motion"
			"LEAD"	Coupling type "Master Value Coupling"
			"EG"	Coupling type "Electronic gearbox"
			"COUP"	Coupling type "Synchronized spindle"

FAx: following axis/spindle

LAx: leading axis/spindle

Note

Coupling characteristics, which are not explicitly programmed (in part program of synchronous actions), become effective with their default settings.

Depending on the settings of the keyword `CPSETTYPE` instead of the default settings (`CPSETTYPE="CP"`) preset coupling characteristics can become effective.

References

For detailed information on generic couplings, see:

- Function Manual, Special Functions; M3: Axis couplings, Chapter: "Generic coupling"

11.7 Master/slave coupling (MASLDEF, MASLDEL, MASLON, MASLOF, MASLOFS)

Function

The "master/slave coupling" enables:

- The coupling of the slave axes to their master axis, when the axes involved are at standstill.
- The coupling/decoupling of **rotating**, speed-controlled spindles.
- The dynamic configuration.

Note

For axes and spindles in the positioning mode, the coupling is only closed and opened at standstill.

Syntax

```
MASLON(<slave_1>,<slave_2>,...)
MASLOF(<slave_1>,<slave_2>,...)
MASLOFS(<slave_1>,<slave_2>,...)
```

Dynamic configuration:

```
MASLDEF(<slave_1>,<slave_2>, ... ,<master>)
MASLDEL(<slave_1>,<slave_2>,...)
```

Meaning

MASLON:	Activating a temporary master/slave coupling	
	<slave_1>,...:	Slave axes Axes that are to be controlled by a master axis in a master/slave group
MASLOF:	Decoupling an active master/slave coupling	
	<slave_1>,...:	Slave axes
MASLOFS:	Decoupling a master/slave coupling and automatically braking slave spindles (see note "Coupling behavior for spindles! in speed control mode"!)	
	<slave_1>,...:	Slave axes
MASLDEF:	Creating/changing a master/slave group from the part program	
	<slave_1>,...:	Slave axes
	<master>:	Master axis Axis that is to control defined slave axes in a master/slave group

MASLDEL: Separate master/slave coupling and delete the definition of the grouping

<slave_1>,...: Slave axes

Note:
The master/slave definitions configured in the machine data are retained.

Note

Coupling behavior for spindles in speed control mode

For spindles in the speed control mode, the coupling behavior of MASLON, MASLOF, MASLOFS and MASLDEL are specified explicitly via the following machine data:

MD37263 $MA_MS_SPIND_COUPLING_MODE

For the default setting with MD37263 = 0, the slave axes are coupled-in and coupled-out only when the axes involved are at standstill. MASLOFS corresponds to MASLOF.

For MD37263 = 1, the coupling instruction is immediately executed and therefore also the motion. For MASLON the coupling is immediately closed and for MASLOFS or MASLOF immediately opened. With MASLOF, the slave spindles rotating at this instant keep their speeds until a new speed is programmed. However, with MASLOFS, they are braked automatically.

Note

For MASLOF/MASLOFS, the implicit preprocessing stop is not required. Because of the missing preprocessing stop, the $P system variables for the slave axes do not provide updated values until next programming.

Note

For the slave axis, the actual value can be synchronized to the same value of the master axis using PRESETON. To do this, the permanent/slave coupling must be briefly switched off in order to set the actual value of the non-referenced slave axis to the value of the master/axis with Power On. Then the coupling is permanently re-established.

The permanent master/slave coupling is activated with the following MD setting:
MD37262 $MA_MS_COUPLING_ALWAYS_ACTIVE = 1
It has no effect on the language commands of the temporary coupling.

Examples

Example 1: Dynamic configuration of a master/slave coupling

Dynamic configuration of a master/slave coupling from the part program.
The axis relevant after axis container rotation is to become the master axis.

```
Program code          Comment
MASLDEF(AUX,S3)       ; S3 master for AUX
MASLON(AUX)           ; Close coupling for AUX
M3=3 S3=4000          ; Clockwise direction of rotation
MASLDEL(AUX)          ; Delete configuration and open the coupling
AXCTSWE(CT1)          ; Container rotation
```

Example 2: Actual-value coupling of a slave axis

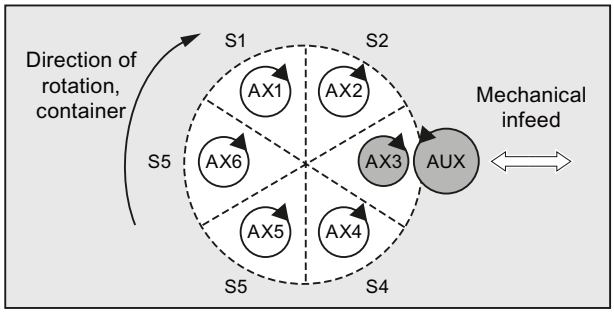
Actual value coupling of a slave axis to the same value of the master axis using PRESETON. For a permanent master/slave coupling, the actual value at the slave axis is to be changed using PRESETON.

```
Program code                                    Comment
N37262 $MA_MS_COUPLING_ALWAYS_ACTIVE[AX2]=0     ; Briefly switch-out the
                                                  permanent coupling.
N37263 NEWCONF
N37264 STOPRE
MASLOF(Y1)                                      ; Temporary coupling open.
N5 PRESETON(Y1,0,Z1,0,B1,0,C1,0,U1,0)           ; Set the actual value of
                                                  the non-referenced slave
                                                  axes as these are
                                                  activated with Power On.
N37262 $MA_MS_COUPLING_ALWAYS_ACTIVE[AX2]=1     ; Activate permanent
                                                  coupling.
N37263 NEWCONF
```

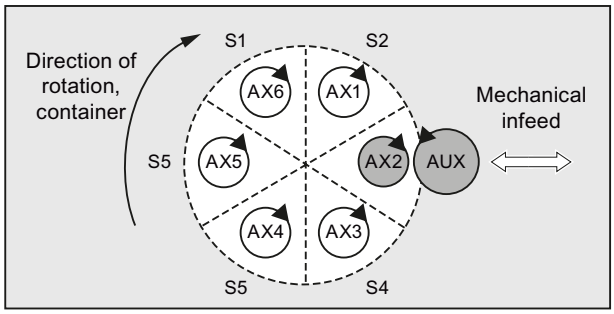
Example 3: Coupling sequence, position 3 / container CT1

To enable coupling with another spindle after container rotation, the previous coupling must be uncoupled, the configuration cleared, and a new coupling configured.

Initial situation:



After rotation by one slot:



Synchronized actions 12

12.1 Definition of a synchronized action

A synchronized action is defined in a block of a part program. Any further commands that are not part of the synchronized action, may not be programmed within this block.

A synchronized action consists of the following components:

Condition part				Action part		
Optional	Optional					
Validity, ID no.	Frequency	Optional G function	Condition	Keyword	Optional: G function	Actions
NS	NS	G...	Logical expression	DO	G...	Action 1 ... Action n
ID=<no.>	WHENEVER					
IDS=<no.>	FROM					
	WHEN					
	EVERY					
NS = "No specification"						

Syntax

```
DO <action 1> ... <action n>
<frequency> [<G function>] <condition> DO <action 1> ... <action n>
ID=<No> <frequency> [<G function>] <condition> DO <action 1> ...
<action n>
IDS=<No> <frequency> [<G function>] <condition> DO <action 1> ...
<action n>
```

References

A detailed description of the functionality of synchronized actions can be found in:

Function Manual, Synchronized Actions

Oscillation

13

13.1 Asynchronous oscillation (OS, OSP1, OSP2, OST1, OST2, OSCTRL, OSNSC, OSE, OSB)

Function

An oscillating axis travels back and forth between two reversal points 1 and 2 at a defined feedrate, until the oscillating motion is deactivated.

Other axes can be interpolated as desired during the oscillating motion. A continuous infeed can be achieved via a path movement or with a positioning axis, however, there is **no relationship** between the oscillating movement and the infeed movement.

Properties of asynchronized oscillation

- Asynchronous oscillation is active on an axis-specific basis beyond block limits.
- Block-oriented activation of the oscillation movement is ensured by the part program.
- Combined interpolation of several axes and superimposing of oscillation paths are not possible.

Programming

The following commands can be used to activate and control asynchronous oscillation from the part program.

The programmed values are entered in the corresponding setting data with block synchronization during the main run and remain active until changed again.

Syntax

```
OSP1[<axis>]=<value> OSP2[<axis>]=<value>
OST1[<axis>]=<value> OST2[<axis>]=<value>
FA[<axis>]=<value>
OSCTRL[<axis>]=(<setting option>,<reset option>)
OSNSC[<axis>]=<value>
OSE[<axis>]=<value>
OSB[<axis>]=<value>
OS[<axis>] = 1
OS[<axis>] = 0
```

Meaning

`<axis>` Name of oscillating axis

`OS` Activate/deactivate oscillation

Value: 1 Switch oscillation **on**

0 Switch oscillation **off**

`OSP1` Define position of reversal point 1

`OSP2` Define position of reversal point 2

Note:
If incremental movement is active, the position will be calculated incrementally to the last corresponding reversal position programmed in the NC program.

`OST1` Define stopping time in reversal point 1 in [s]

`OST2` Define stopping time in reversal point 2 in [s]

`<value>`:
- -2 Interpolation continues without wait for exact stop
- -1 Wait for exact stop coarse
- 0 Wait for exact stop fine
- >0 Wait for exact stop fine and then wait for specified stopping time

  Note:
  The unit for the stopping time is identical to that of the stopping time programmed with `G4`.

`FA` Define feedrate

The feedrate is the defined feedrate of the positioning axis. If no feedrate is defined, the value stored in the machine data applies.

`OSCTRL` Specify setting and reset options

Option values 0 to 3 encrypt the behavior at the reversal points on deactivation. One of the variants from 0 to 3 can be selected. The remaining settings can be combined at will with the selected variant. Multiple options are appended with plus characters (+).

`<value>`:
- 0 Stop at next reversal point on deactivation of oscillation (default)

  Note:
  Only possible if values 1 and 2 are reset.
- 1 When the oscillation is deactivated, stop at reversal point 1
- 2 When the oscillation is deactivated, stop at reversal point 2
- 3 When the oscillation is deactivated, do not approach reversal point if no spark-out strokes are programmed
- 4 Approach end position after spark-out
- 8 If oscillation is canceled by deletion of distance-to-go, sparking-out strokes will then need to be executed and the end position approached if necessary.
- 16 If oscillation is canceled by deletion of distance-to-go, the corresponding reversal point will need to be approached as is the case with shutdown.

32 New feed is only active after the next reversal point

64 FA equal to 0, FA = 0: Path overlay is active
FA not equal to 0, FA <> 0: Speed overlay is active

128 For rotary axis DC (shortest path)

256 The sparking-out stroke is a dual stroke (default). 1=Single stroke.

512 First approach start position

`OSNSC` Define number of sparking-out strokes

`OSE` Define end position (in workpiece coordinate system) to be approached after deactivation of oscillation.

Note:
When programming `OSE` option 4 becomes effective implicitly for `OSCTRL`.

`OSB` Define start position (in workpiece coordinate system) to be approached prior to activation of oscillation.

The start position is approached before reversal point 1. If the start position coincides with reversal position 1, reversal position 2 is approached next. No stopping time applies when the start position is reached, even if this position coincides with reversal position 1; instead, the axis waits for the exact stop fine signal. Any exact stop condition configured is fulfilled.

Note:
Bit 9 in setting data SD43770 $SA_OSCILL_CTRL_MASK must be set to initiate an approach to the start position.

Examples

Example 1: Oscillating axis to oscillate between two reversal points

Oscillating axis Z is to oscillate between position 10 and 100. Reversal point 1 is to be approached with exact stop fine, reversal point 2 with exact stop coarse. The feedrate for the oscillating axis must be 250. 3 sparking-out strokes must be executed at the end of the machining operation and the oscillating must approach end position 200. The feedrate for the infeed axis must be 1 and the end of infeed in the X direction should be reached at position 15.

```
Program code                          Comment
WAITP(X,Y,Z)                          ; Starting position.
G0 X100 Y100 Z100                     ; Changeover to positioning axis
                                        operation.
WAITP(X,Z)
OSP1[Z]=10 OSP2[Z]=100                ; Reversal point 1, reversal point 2.
OSE[Z]=200                            ; End position.
```

Program code	Comment
OST1[Z]=0 OST2[Z]=-1	; Stopping time at U1: Exact stop fine
	; Stopping time at U2: Exact stop coarse
FA[Z]=250 FA[X]=1	; Feedrate for oscillating axis, feedrate for infeed axis.
OSCTRL[Z]=(4,0)	; Setting options.
OSNSC[Z]=3	; 3 sparking-out strokes.
OS[Z]=1	; Start oscillation.
WHEN $A_IN[3]==TRUE DO DELDTG(X)	; Deletion of distance-to-go.
POS[X]=15	; Starting position X axis.
POS[X]=50	End position X axis.
OS[Z]=0	; Stop oscillation.
M30	

Note

The OSP1[Z]=... to OSNCS[Z]=... command sequence can also be programmed in a block.

Example 2: Oscillation with online modification of the reversal position

The setting data necessary for asynchronous oscillation can be set in the part program.

If the setting data is described directly in the program, the change takes effect during preprocessing. A synchronized response can be achieved by means of a preprocessing stop (STOPRE).

Program code	Comment
$SA_OSCILL_REVERSE_POS1[Z]=-10	
$SA_OSCILL_REVERSE_POS2[Z]=10	
G0 X0 Z0	
WAITP(Z)	
ID=1 WHENEVER $AA_IM[Z] < $$AA_OSCILL_REVERSE_POS1[Z] DO $AA_OVR[X]=0	; If the actual value of the oscillating axis has exceeded the reversal point, then the infeed axis is stopped.
ID=2 WHENEVER $AA_IM[Z] < $$AA_OSCILL_REVERSE_POS2[Z] DO $AA_OVR[X]=0	
OS[Z]=1 FA[X]=1000 POS[X]=40	; Activate oscillation.
OS[Z]=0	; Deactivate oscillation.
M30	

Further information

Oscillating axis

The following apply to the oscillating axis:

- Every axis may be used as an oscillation axis.
- Several oscillation axes can be active at the same time (maximum: the number of the positioning axes).
- Linear interpolation G1is always active for the oscillating axis – irrespective of the G command currently valid in the program.

The oscillating axis can:

- Act as an input axis for dynamic transformation
- Act as a guide axis for gantry and coupled-motion axes
- Be traversed:
  - Without jerk limit (BRISK)

    or
  - With jerk limit (SOFT)

    or
  - With acceleration curve with a knee (as positioning axes)

Oscillation reversal points

The current offsets must be taken into account when oscillation positions are defined:

- Absolute specification

  ```
  OSP1[Z]=<value>
  ```

  Position of reversal point = sum of offsets + programmed value
- Relative specification

  ```
  OSP1[Z]=IC(<value>)
  ```

  Position of reversal point = reversal point 1 + programmed value

Example:

Program code
N10 OSP1[Z]=100 OSP2[Z]=110
...
...
N40 OSP1[Z]=IC(3)

WAITP

If oscillation is to be performed with a geometry axis, this axis must be enabled for oscillation with WAITP.

When oscillation has finished, WAITP is used to enter the oscillating axis as a positioning axis again, so that normal use can resume.

Oscillation with motion-synchronous actions and stopping times

Once the set stop times have expired, the internal block change is executed during oscillation (indicated by the new distances to go of the axes). The deactivation function is checked when the block changes. The deactivation function is defined according to the control setting for the motion sequence (OSCTRL). *This dynamic response can be influenced by the feed override.*

An oscillation stroke may then be executed before the sparking-out strokes are started or the end position approached. *Although it appears as if the deactivation response has changed, this is not in fact the case.*

13.2 Oscillation controlled by synchronized actions (OSCILL)

Function

With this mode of oscillation, an infeed motion may only be executed at the reversal points or within defined reversal areas.

Depending on requirements, the oscillation movement can be

- Continued or
- Stopped until the infeed has finished executing.

Syntax

1. **Define parameters for oscillation**
2. **Define motion-synchronous actions**
3. **Assign axes, define infeed**

Meaning

`OSP1[<oscillating axis>]=`	Position of reversal point 1
`OSP2[<oscillating axis>]=`	Position of reversal point 2
`OST1[<oscillating axis>]=`	Stopping time at reversal point 1 in seconds
`OST2[<oscillating axis>]=`	Stopping time at reversal point 2 in seconds
`FA[<oscillating axis>]=`	Feed for oscillating axis
`OSCTRL[<oscillating axis>]=`	Set or reset options
`OSNSC[<oscillating axis>]=`	Number of sparking-out strokes
`OSE[<oscillating axis>]=`	End position
`WAITP(<oscillating axis>)`	Enable axis for oscillation

Axis assignment, infeed

```
OSCILL[<oscillating axis>]=(<infeed axis 1>,<infeed axis 2>,<infeed
axis 3>)
POSP[<infeed axis>]=(<end position>,<partial length>,<mode>)
```

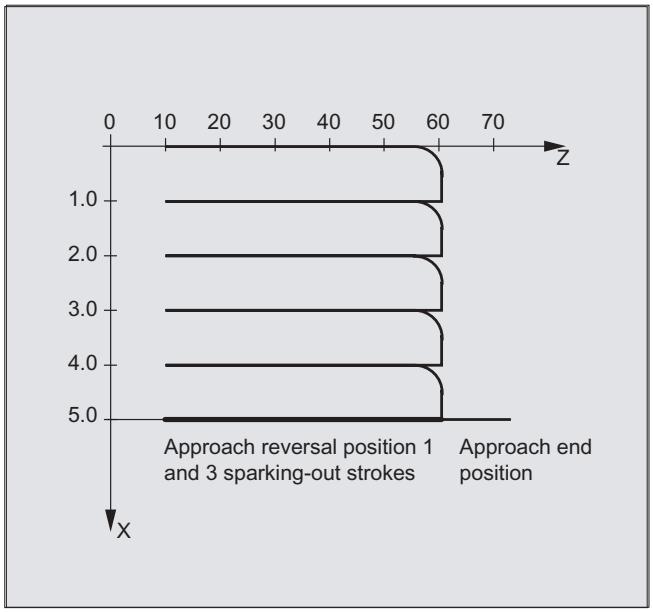
`OSCILL`:	Assign infeed axis or axes for oscillating axis
`POSP`:	Define complete and partial infeeds (see Section "File and Program Management")
`End position`:	End position for the infeed axis after all partial infeeds have been traversed.
`Partial length`:	Length of the partial infeed at reversal point/reversal area
`Mode`:	Division of the complete infeed into partial infeeds = Two residual steps of equal size (default); = All partial infeeds of equal size

Motion-synchronous actions

`WHEN… … DO`	when…, do…
`WHENEVER … DO`	whenever…, do…

Example

No infeed must take place at reversal point 1. At reversal point 2, the infeed is to start at a distance of ii2 before reversal point 2 and the oscillating axis is not to wait at the reversal point for the end of the partial infeed. Axis Z is the oscillation axis and axis X the infeed axis.



1. Parameters for oscillation

Program code		Comment
DEF INT ii2	;	Define variable for reversal area 2
OSP1[Z]=10 OSP2[Z]=60	;	Define reversal points 1 and 2
OST1[Z]=0 OST2[Z]=0	;	Reversal point 1: Exact stop fine Reversal point 2: Exact stop fine
FA[Z]=150 FA[X]=0.5	;	Oscillating axis Z feedrate, infeed axis X feedrate
OSCTRL[Z]=(2+8+16.1)	;	Deactivate oscillating motion at reversal point 2; after delete DTG spark-out and approach end position; after delete DTG approach reversal position
OSNC[Z]=3	;	Sparking-out strokes
OSE[Z]=70	;	End position = 70
ii2=2	;	Set reversal point range
WAITP(Z)	;	Enable oscillation for Z axis

2. Motion-synchronous action

Program code		Comment
WHENEVER $AA_IM[Z]<$SA_OSCILL_REVERSE_POS2[Z] DO -> $AA_OVR[X]=0 $AC_MARKER[0]=0	;	If the actual position of oscillating axis Z in MCS is less than the start of reversal range 2, then always set the axial override of the infeed axis X to 0% and the bit memory with index 0 to the value 0.
WHENEVER $AA_IM[Z]>=$SA_OSCILL_REVERSE_POS2[Z] DO $AA_OVR[Z]=0	;	If the actual position of the oscillating axis Z in MCS is greater than the reversal position 2, then always set the axial override of the oscillating axis Z to 0%.
WHENEVER $AA_DTEPW[X] == 0 DO $AC_MARKER[0]=1	;	If the remaining distance to go of the partial infeed is 0, then always set the bit memory with index 0 to the value 1.
WHENEVER $AC_MARKER[0]==1 DO $AA_OVR[X]=0 $AA_OVR[Z]=100	;	Whenever the bit memory with index 0 is equal to 1, then set the axial override of the infeed axis X to 0%. As a consequence, a premature infeed is prevented (oscillating axis Z has still not left reversal area 2, but infeed axis X is ready for a new infeed). Set the axial override of oscillating axis Z from 0% (action of the 2nd synchronized action) back to 100% to move.

-> must be programmed in a single block

3. Start oscillation

```
Program code                                    Comment
OSCILL[Z]=(X) POSP[X]=(5,1,1)                   ; Start the axes
                                                  Oscillating axis Z is assigned
                                                  axis X as infeed axis.
                                                  Up to end position 5, axis X
                                                  should travel in steps of 1.
M30                                             ; End of program
```

Description

1. **Define oscillation parameters**
   The parameters for oscillation should be defined before the movement block containing the assignment of infeed and oscillating axes and the infeed definition (see "Asynchronized oscillation").
2. **Define motion-synchronized actions**
   The following synchronization conditions can be defined:
   Suppress infeed until the oscillating axis is located within a reversal area (ii1, ii2) or at a reversal point (U1, U2).
   Stop oscillation motion during infeed at reversal point.
   Restart oscillation movement on completion of partial infeed. Define **start of next partial infeed**.
3. **Assign oscillating and infeed axes** as well as **partial and complete infeed**.

Define oscillation parameters

Assignment of oscillating and infeed axes: OSCILL

```
OSCILL[oscillating axis] = (infeed axis1, infeed axis2, infeed axis3)
```

The axis assignments and the start of the oscillation movement are defined with the `OSCILL` command.

Up to 3 infeed axes can be assigned to an oscillating axis.

Note

Before oscillation starts, the synchronization conditions must be defined for the behavior of the axes.

Define infeeds: POSP

```
POSP[infeed axis] = (End pos, partial length, mode)
```

The following are declared to the controller with the `POSP` command:

- Complete infeed (with reference to end position)
- The length of the partial infeed at the reversal point or in the reversal area
- The partial infeed response when the end position is reached (with reference to mode)

Mode = 0	The distance-to-go to the destination point for the last two partial infeeds is divided into two equal steps (default setting).
Mode = 1	All partial infeeds are of equal size. They are calculated from the complete infeed.

Define motion-synchronized actions

The synchronized-motion actions listed below are used for general oscillation.

You are given example solutions for individual tasks, which you can use as modules for creating user-specific oscillation movements

Note

In individual cases, the synchronization conditions can be programmed differentially.

Keywords

`WHEN … DO …`	when…, do…
`WHENEVER … DO`	whenever…, do…

Functions

You can implement the following functions with the language resources described in detail below:

1. Infeed at reversal point.
2. Infeed at reversal area.
3. Infeed at both reversal points.
4. Stop oscillation movement at reversal point.
5. Restart oscillation movement.
6. Do not start partial infeed too early.

The following assumptions are made for all examples of synchronized actions presented here:

- Reversal point 1 < reversal point 2
- Z = oscillating axis
- X = infeed axis

Note

For more details, see the "Motion-synchronous actions" section.

Assign oscillating and infeed axes as well as partial and complete infeed

Infeed in reversal point range

The infeed motion must start within a reversal area before the reversal point is reached.

These synchronized actions inhibit the infeed movement until the oscillating axis is within the reversal area.

The following instructions are used subject to the above assumptions:

Reversal range 1:

```
WHENEVER
$AA_IM[Z]>$SA_OSCILL_RESERV
E_POS1[Z]+ii1 DO $AA_OVR[X]
=0
```

Whenever the actual position of the oscillating axis in the MCS is greater than the start of reversal range 1, then set the axial override of the infeed axis to 0%.

Reversal range 2:

```
WHENEVER
$AA_IM[Z]<$SA_OSCILL_RESERV
E_POS2[Z]+ii2 DO $AA_OVR[X]
=0
```

Whenever the actual position of the oscillating axis in the MCS is less than the start of reversal range 2, then set the axial override of the infeed axis to 0%.

Infeed at reversal point

As long as the oscillation axis has not reached the reversal point, the infeed axis does not move.

The following instructions are used subject to the above assumptions:

Reversal range 1:

```
WHENEVER
$AA_IM[Z]<>$SA_OSCILL_RESER
VE_POS1[Z] DO $AA_OVR[X] =
0 ⇒
→ $AA_OVR[Z] = 100
```

Whenever the actual position of oscillating axis Z in MCS is greater or less than the position reversal point 1, then set the axial override of the infeed axis X to 0% and the axial override of the oscillating axis Z to 100%.

Reversal range 2:

For reversal point 2:

```
WHENEVER
$AA_IM[Z]<>$SA_OSCILL_RESER
VE_POS2[Z] DO $AA_OVR[X] =
0 ⇒
→ $AA_OVR[Z] = 100
```

Whenever the actual position of oscillating axis Z in MCS is greater or less than the position reversal point 2, then set the axial override of the infeed axis X to 0% and the axial override of the oscillating axis Z to 100%.

Stop oscillation movement at the reversal point

The oscillation axis is stopped at the reversal point, the infeed motion starts at the same time. The oscillating motion is continued when the infeed movement is complete.

At the same time, this synchronized action can be used to start the infeed movement if this has been stopped by a previous synchronized action, which is still active.

The following instructions are used subject to the above assumptions:

Reversal range 1:

```
WHENEVER
$SA_IM[Z]==$SA_OSCILL_RESER
VE_POS1[Z] DO $AA_OVR[X] =
0 →
→ $AA_OVR[Z] = 100
```

Whenever the actual position of the oscillating axis in the MCS is the same as the reversal position 1, then set the axial override of the oscillating axis to 0% and the axial override of the infeed axis to 100%.

Reversal range 2:

```
WHENEVER
$SA_IM[Z]==$SA_OSCILL_RESER
VE_POS2[Z] DO $AA_OVR[X] =
0 →
→ $AA_OVR[Z] = 100
```

Whenever the actual position of the oscillating axis Z in the MCS is the same as the reversal position 2, then set the axial override of the oscillating axis X to 0% and the axial override of the infeed axis to 100%.

Online evaluation of reversal point

If there is a main run variable coded with `$$` on the right of the comparison, then the two variables are evaluated and compared with one another continuously in the IPO cycle.

Note

Please refer to Section "Motion-synchronized actions" for more information.

Oscillation movement restarting

The purpose of this synchronized action is to continue the movement of the oscillation axis on completion of the part infeed movement.

The following instructions are used subject to the above assumptions:

```
WHENEVER $AA_DTEPW[X]==0 DO
$AA_OVR[Z]= 100
```

Whenever the remaining distance for the partial infeed of infeed axis X in the WCS is equal to zero, then set the axial override of the oscillating axis to 100%.

Next partial infeed

When infeed is complete, a premature start of the next partial infeed must be inhibited.

A channel-specific marker (`$AC_MARKER[Index]`) is used for this purpose. It is enabled at the end of the partial infeed (partial distance-to-go ≡ 0) and deleted when the axis leaves the reversal area. The next infeed movement is then prevented by a synchronized action.

On the basis of the given assumptions, the following instructions apply for reversal point 1:

1. Set marker:

```
WHENEVER $AA_DTEPW[X] == 0
DO $AC_MARKER[1]=1
```

Whenever the remaining distance for the partial infeed of infeed axis X in the WCS is equal to zero, then set the bit memory with index 1 to 1.

2. Delete marker

```
WHENEVER $AA_IM[Z]<>
$SA_OSCILL_RESERVE_POS1[Z]
DO $AC_MARKER[1] =¯0
```

Whenever the actual position of oscillating axis Z in the MCS is greater or less than the position of reversal point 1, then set the bit memory 1 to 0.

3. Inhibit infeed

```
WHENEVER $AC_MARKER[1]==1
DO $AA_OVR[X]=0
```

Whenever bit memory 1 is the same, then set the axial override of the infeed axis X to 0%.

Punching and nibbling 14

14.1 Activation, deactivation

14.1.1 Punching and nibbling on or off (SPOF, SON, PON, SONS, PONS, PDELAYON, PDELAYOF, PUNCHACC)

Function

Activate/deactivate punching and nibbling

PON and SON are used to activate the punching and nibble functions. SPOF terminates all punching- and nibble-specific functions. Modal commands PON and SON are mutually exclusive, i.e. PON deactivates SON and vice versa.

Punching/nibbling with leader

The functions SONS and PONS also switch-in the punching or nibbling functions.

Unlike SON/PON (stroke control at interpolation level), with these functions, signal-related control of stroke initiation is at servo level. This enables higher stroke frequencies and, as a result, increased punching capacity to be achieved.

While signals are being evaluated in the leader, all functions that cause the nibbling or punching axes to change position (e.g. handwheel travel, changes to frames via PLC, measurement functions) are inhibited.

Punching with delay

PDELAYON results in a delayed output of the punching stroke. The modally effective command has a preparatory function and therefore is generally located before PON. Normal punching resumes after PDELAYOF.

Note

The delay time is set in setting data SD42400 $SC_PUNCH_DWELLTIME.

Travel-dependent acceleration

PUNCHACC can be used to specify an acceleration characteristic defining different rates of acceleration dependent on the hole spacing.

Second punching interface

Machines which need to use a second punching interface (second punching unit or comparable medium) alternately can be switched over to a second pair of fast digital inputs and outputs on the controller (I/O pair). Full punching/nibbling functionality is available on both interfaces. The `SPIF1` and `SPIF2` commands are used to switch over between the first and second punching interface.

Note

Requirement: A second I/O pair has to be defined for the punching functionality in the machine data (→ see machine manufacturer's specifications).

Syntax

```
PON G... X... Y... Z...
SON G... X... Y... Z...
SONS G... X... Y... Z...
PONS G... X... Y... Z...
PDELAYON
PDELAYOF
PUNCHACC(<Smin>,<Amin>,<Smax>,<Amax>)
SPIF1/SPIF2
SPOF
```

Meaning

`PON`	Activate punching.
`SON`	Activate nibbling
`PONS`	Activate punching with leader.
`SONS`	Activate nibbling with leader.
`SPOF`	Deactivate punching/nibbling.
`PDELAYON`	Activate punching with delay.
`PDELAYOF`	Deactivate punching with delay.
`PUNCHACC`	Activate travel-dependent acceleration. Parameter: `<Smin>` Minimum hole spacing `<Amin>` Initial acceleration `<Amin>` can be greater than `<Amax>`. `<Smax>` Maximum hole spacing `<Amax>` Final acceleration `<Amax>` can be greater than `<Amin>`.

SPIF1	Activate **first** punching interface. The stroke is controlled using the first pair of fast I/O.
SPIF2	Activate **second** punching interface. The stroke is controlled using the second pair of fast I/O.

Note:
The first punch interface is always active after a RESET or control system power up. If only one punching interface is used, then it need not be programmed.

Examples

Example 1: Activate nibbling

```
Program code                    Comment
...
N70 X50 SPOF                    ; Position without punch initiation.
N80 X100 SON                    ; Activate nibbling, initiate a stroke before the
                                  motion (X=50) and on completion of the programmed
                                  movement (X=100).
...
```

Example 2: Punching with delay

```
Program code                    Comment
...
N170 PDELAYON X100 SPOF         ; Position without punch initiation, activate delayed
                                  punch initiation.
N180 X800 PON                   ; Activate punching. The punch stroke is output with
                                  a delay when the end position is reached.
N190 PDELAYOF X700              ; Deactivate punching with delay, normal punch
                                  initiation on completion of the programmed
                                  movement.
...
```

Example 3: Punching with two punching interfaces

```
Program code                    Comment
...
N170 SPIF1 X100 PON             ; At the end of the block, a stroke is initiated at
                                  the first fast output. The "Stroke active" signal
                                  is monitored at the first input.
N180 X800 SPIF2                 ; The second stroke is initiated at the second fast
                                  output. The "Stroke active" signal is monitored at
                                  the second input.
N190 SPIF1 X700                 ; All further strokes are controlled with the first
                                  interface.
...
```

Further information

Punching and nibbling with leader (PONS/SONS)

Punching and nibbling with leader is not possible in more than one channel simultaneously. `PONS` or `SONS` can only be activated in one channel at a time.

Travel-dependent acceleration (PUNCHACC)

Example:
```
PUNCHACC(2,50,10,100)
```

Distance between holes less than 2 mm:

The axis accelerates at a rate corresponding to 50% of maximum acceleration.

Distance between holes from 2 mm to 10 mm:

Acceleration is increased to 100%, proportional to the spacing.

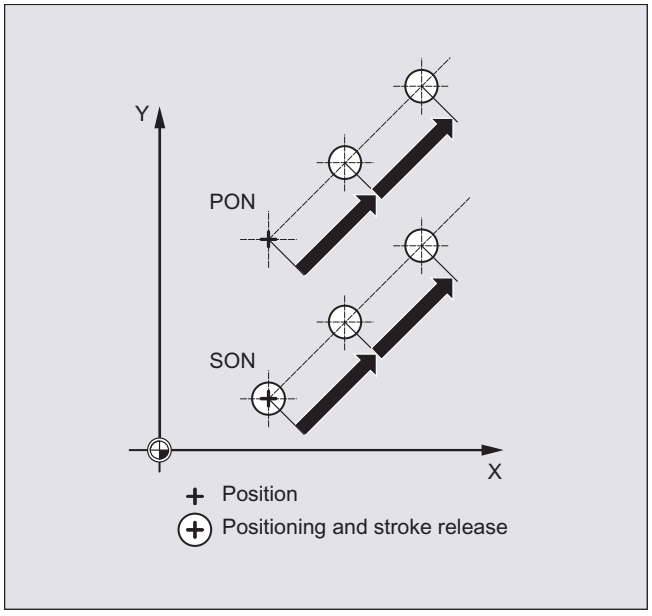
Distance between holes more than 10 mm:

Traverse at an acceleration of 100%.

Initiation of the first stroke

The instant at which the first stroke is initiated after activation of the function differs depending on whether nibbling or punching is selected:

- `PON/PONS`:
  - All strokes - even the one in the first block after activation - are executed at the block end.
- `SON/SONS`:
  - The first stroke after activation of the nibbling function is executed at the start of the block.
  - Each of the following strokes is initiated at the block end.



Punching and nibbling on the spot

A stroke is initiated only if the block contains traversing information for the punching or nibbling axes (axes in active plane).

However, to initiate a stroke at the same position, one of the punching/nibbling axes can be programmed with a traversing path of 0.

Machining with rotatable tools

Note

Use the tangential control function if you wish to position rotatable tools at a tangent to the programmed path.

Use of M commands

As in earlier versions, macro technology allows special M functions to be used instead of language commands (compatibility). The M functions and equivalent language commands as used in earlier systems are as follows:

```
M20, M23      ≙   SPOF
M22           ≙   SON
M25           ≙   PON
M26           ≙   PDELAYON
```

Example for macro file:

```
Program code                    Comment
DEFINE M25 AS PON               ; Punching on
DEFINE M125 AS PONS             ; Punching with leader on
DEFINE M22 AS SON               ; Nibbling on
DEFINE M122 AS SONS             ; Nibbling with leader on
DEFINE M26 AS PDELAYON          ; Punching with delay on
DEFINE M20 AS SPOF              ; Punching, nibbling off
DEFINE M23 AS SPOF              ; Punching, nibbling off
```

Programming example:

```
Program code                    Comment
...
N100 X100 M20                   ; Position without punch initiation.
N110 X120 M22                   ; Activate nibbling, initiate stroke before and
                                  after motion,
N120 X150 Y150 M25              ; Activate punching, initiate stroke at end of
                                  motion.
...
```

14.2 Automatic path segmentation

Function

Segmentation into path segments

When punching or nibbling is activated, both SPP as well as also SPN segment the total traversing section programmed for the path axes into a number of path segments with the same length (equidistant path segmentation). Internally, each path segment corresponds to a block.

Number of strokes

When punching, the first stroke is realized at the end point of the first path segment; on the other hand for nibbling, at the starting point of the first path segment. Therefore the following numbers are obtained over the complete traversing section:

Punching: Number of strokes = number of path segments

Nibbling: Number of strokes = number of path segments +1

Auxiliary functions

Auxiliary functions are executed in the first of the generated blocks.

Syntax

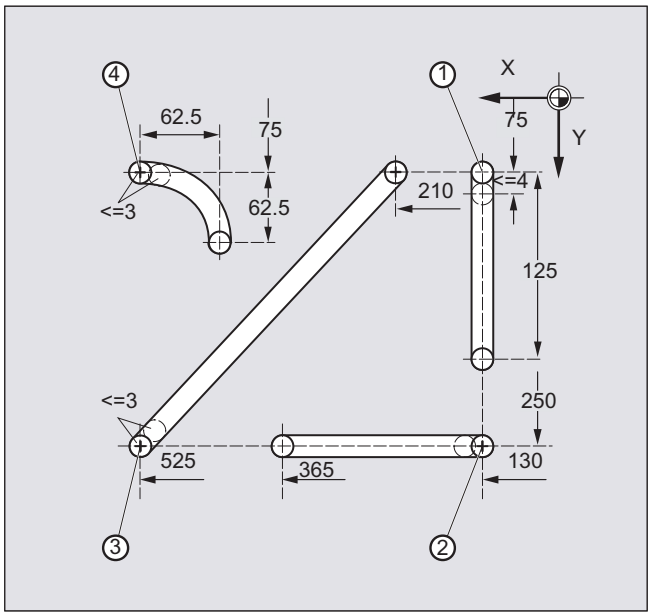
```
SPP=

SPN=
```

Meaning

SPP	Size of path segment (maximum distance between strokes); modal
SPN	Number of path segments per block; modally effective

Example 1

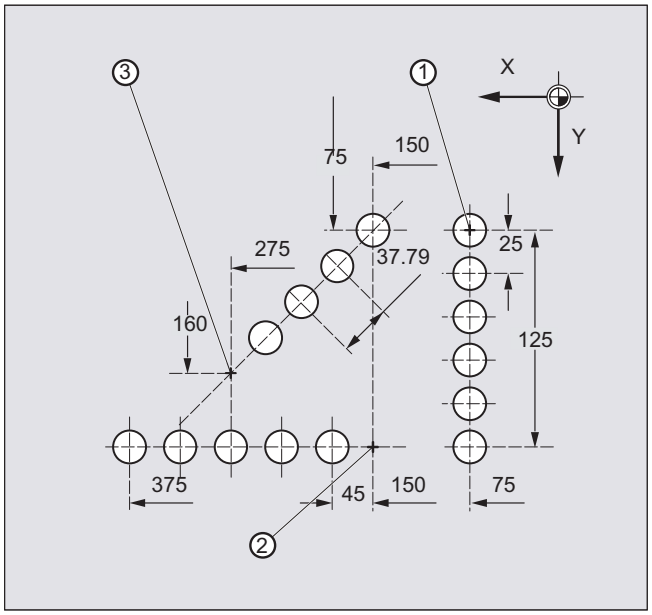
The programmed nibbling segments should be automatically split-up into path segments.



Program code	Comment
N100 G90 X130 Y75 F60 SPOF	; Positioning at starting point 1
N110 G91 Y125 SPP=4 SON	; Nibbling on; maximum path segment length for automatic path segmentation: 4 mm
N120 G90 Y250 SPOF	; Nibbling off; positioning to starting point 2
N130 X365 SON	; Nibbling on; maximum path segment length for automatic path segmentation: 4 mm
N140 X525 SPOF	; Nibbling off; positioning to starting point 3
N150 X210 Y75 SPP=3 SON	; Nibbling on; maximum path segment length for automatic path segmentation: 3 mm
N160 X525 SPOF	; Nibbling off; positioning to starting point 4
N170 G02 X-62.5 Y62.5 I J62.5 SPP=3 SON	; Nibbling on; maximum path segment length for automatic path segmentation: 3 mm
N180 G00 G90 Y300 SPOF	; Nibbling off

Example 2

Automatic path segmentation should be made for the individual series of holes. The maximum path segment length (SPP value) is specified for the segmentation.



Program code		Comment
N100 G90 X75 Y75 F60 PON	;	Position to starting point 1; punch an individual hole
N110 G91 Y125 SPP=25	;	Maximum path segment length for automatic path segmentation: 25 mm
N120 G90 X150 SPOF	;	Punching off; positioning to starting point 2
N130 X375 SPP=45 PON	;	Punching on; maximum path segment length for automatic path segmentation: 45 mm
N140 X275 Y160 SPOF	;	Punching off; positioning to starting point 3
N150 X150 Y75 SPP=40 PON	;	Punching on, instead of the programmed path segment length of 40 mm, the calculated path segment length of 37.79 mm is used.
N160 G00 Y300 SPOF	;	Punching off; positioning

14.2.1 Path segmentation for path axes

Length of SPP path segment

SPP is used to specify the maximum distance between strokes and thus the maximum length of the path segments in which the total traversing distance is to be divided. The command is deactivated with SPOF or SPP=0.

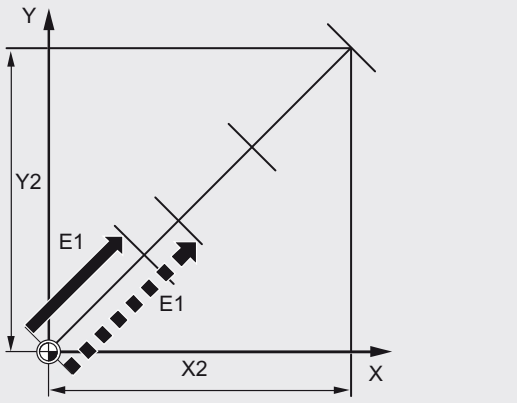
Example:

```
N10 SON X0 Y0
N20 SPP=2 X10
```

The total traversing distance of 10 mm will be divided into five path sections each of 2 mm (SPP=2).

Note

The path segments effected by SPP are always equidistant, i.e. all segments are equal in length. In other words, the programmed path segment size (SPP setting) is valid only if the quotient of the total traversing distance and the SPP value is an integer. If this is not the case, the size of the path segment is reduced internally such as to produce an integer quotient.



X2/Y2 Programmed traverse path (nibbling or punching block)
E1 Programmed path segment length
E1' Automatically rounded path segment length

Example:

```
N10 G1 G91 SON X10 Y10
N20 SPP=3.5 X15 Y15
```

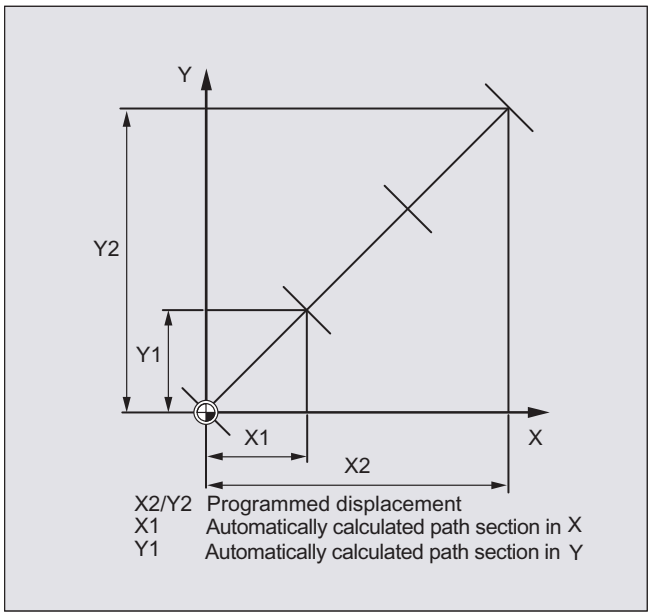
When the total traversing distance is 15 mm and the path segment length 3.5 mm, the quotient is not an integer value (4.28). In this case, the SPP value is reduced down to the next possible integer quotient. The result in this example would be a path segment length of 3 mm.

Number of SPN path segments

SPN defines the number of path segments to be generated from the total traversing distance. The length of the segments is calculated automatically. Since SPN is non-modal, punching or nibbling must be activated beforehand with PON or SON respectively.

SPP and SPN in the same block

If you program both the path segment length (SPP) and the number of path segments (SPN) in the same block, then SPN applies to this block and SPP to all the following blocks. If SPP was activated before SPN, then it takes effect again after the block with SPN.



Note

Provided that punching/nibbling functions are available in the controller, then it is possible to program the automatic path segmentation function with SPN or SPP even independent of this technology.

14.2.2 Path segmentation for single axes

If single axes are defined as punching/nibbling axes in addition to path axes, then the automatic path segmentation function can be activated for them.

Response of single axis to SPP

The programmed path segment length (SPP) basically refers to the path axes. For this reason, the SPP value is ignored in blocks which contain a single axis motion and an SPP value, but not a programmed path axis.

If both a single axis and a path axis are programmed in the block, then the single axis responds according to the setting of the appropriate machine data.

1. Standard setting

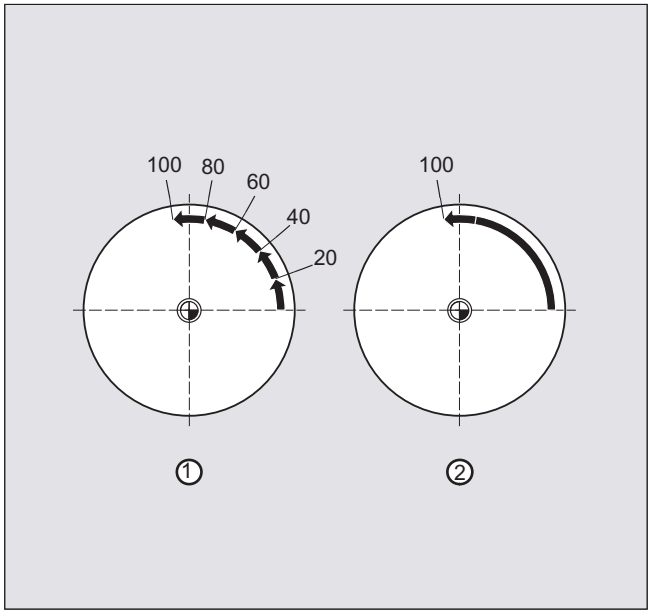
   The path traversed by the single axis is distributed evenly among the intermediate blocks generated by SPP.

Example:

```
N10 G1 SON X10 A0

N20 SPP=3 X25 A100
```

As a result of the programmed distance between strokes of 3 mm, five blocks are generated for the total traversing distance of the X axis (path axis) of 15 mm.

The A axis thus rotates through 20° in every block.



1. Single axis without path segmentation

   The single axis traverses the total distance in the first of the generated blocks.

2. With/without path segmentation

   The response of the single axis depends on the interpolation of the path axes:

- Circular interpolation: Path segmentation
- Linear interpolation: No path segmentation

Response to SPN

The programmed number of path segments is applicable even if a path axis is not programmed in the same block.

Requirement: The single axis is defined as a punching/nibbling axis.

Grinding 15

15.1 Grinding-specific tool monitoring in the part program (TMON, TMOF)

Function

With the TMON command, you can activate geometry and speed monitoring for grinding tools (type 400 - 499) in the NC part program. Monitoring remains active until deactivated in the part program using the TMOF command.

Note

Please follow the machine manufacturer's instructions!

Requirement

The grinding-specific tool parameters $TC_TPG1 to $TC_TPG9 must be set.

Syntax

```
TMON(<T-No.>)
TMOF(<T-No.>)
```

Meaning

TMON	Command to **switch-in** the grinding-specific tool monitoring
TMOF	Command to **switch-out** the grinding-specific tool monitoring
<T-No.>	Specifies the T number **Note:** Only necessary if the tool with this T number is not active.
TMOF(0)	Deactivate monitoring for all tools

Further Information

Grinding-specific tool parameters

Parameters	Significance	Data type
$TC_TPG1	Spindle number	INT
$TC_TPG2	Chaining rule The parameters are automatically kept identical for the lefthand and righthand grinding wheel side.	INT
$TC_TPG3	Minimum wheel radius	REAL
$TC_TPG4	Minimum wheel width	REAL
$TC_TPG5	Current wheel width	REAL
$TC_TPG6	Maximum speed	REAL
$TC_TPG7	Maximum peripheral speed	REAL
$TC_TPG8	Angle of the inclined wheel	REAL
$TC_TPG9	Parameter number for radius calculation	INT

References:
Function Manual Basic Functions; Tool Offset (W1)

Switch-in tool monitoring by selecting a tool

According to the machine data settings, tool monitoring for the grinding tools (types 400-499) can be automatically activated when the tool selection is activated.

Only **one** monitoring routine can be active at any one time for each spindle.

Geometry monitoring

The current wheel radius and the current width are monitored.

The set speed is monitored against the speed limitation cyclically with allowance for the spindle override.

The speed limit is the smaller value resulting from a comparison of the maximum speed with the speed calculated from the maximum wheel peripheral speed and the current wheel radius.

Working without a T or D number

A standard **T** number and standard **D** number can be set per machine data, which do not have to be reprogrammed and are effective after power on/reset.

Example: All machining is performed with the same grinding wheel.

The machine data can be used to set that the active tool remains for a reset (see "Free D number assignment, cutting edge number (Page 424)").

Additional functions 16

16.1 Axis functions (AXNAME, AX, SPI, AXTOSPI, ISAXIS, AXSTRING, MODAXVAL)

Function

AXNAME is used e.g. to generate cycles that are generally valid, if the names of the axes are not known.

AX is used to indirectly program geometry and synchronous axes. The axis identifier is saved in a type AXIS variable or is supplied from a command such as AXNAME or SPI.

SPI is used if axis functions are programmed for a spindle, e.g. a synchronous spindle.

AXTOSPI is used to convert an axis identifier into a spindle index (inverse function to SPI).

AXSTRING is used to convert an axis identifier (data type AXIS) into a string (inverse function to AXNAME).

ISAXIS is used in universal cycles in order to ensure that a specific geometry axis exists and thus that any following $P_AXNX call is not aborted with an error message.

This MODAXVAL is used in order to determine the modulo position for modulo rotary axes.

Syntax

```
AXNAME("string")
AX[AXNAME("string")]
SPI(n)
```

AXTOSPI(A) or AXTOSPI(B) or AXTOSPI(C)

```
AXSTRING( SPI(n) )
ISAXIS(<geometry axis number>)
<Modulo position>=MODAXVAL(<axis>,<axis position>)
```

Meaning

AXNAME	Converts an input string into axis identifiers; the input string must contain a valid axis name.
AX	Variable axis identifier
SPI	Converts the spindle number into an axis identifier; the transfer parameter must contain a valid spindle number.
n	Spindle number
AXTOSPI	Converts an axis identifier into an integer spindle index. AXTOSPI corresponds to the reverse function to SPI.
X, Y, Z	Axis identifier of AXIS type as variable or constant
AXSTRING	The string is output with the associated spindle number.
ISAXIS	Checks whether the specified geometry axis exists.
MODAXVAL	For modulo rotary axes, determines the modulo position; this corresponds to the modulo rest referred to the parameterized modulo range (in the default setting, this is 0 to 360 degrees; the start and size of the modulo range can be changed using MD30340 MODULO_RANGE_START and MD30330 $MA_MODULO_RANGE).

Note

SPI extensions

The axis function SPI(n) can also be used to read and write frame components. This means that frames can be written e.g. with the syntax `$P_PFRAME[SPI(1),TR]=2.22`.

An axis can be traversed by additionally programming axis positions using the address `AX[SPI(1)]=<axis position>`. The prerequisite is that the spindle is either in the positioning or axis mode.

Examples

Example 1: AXNAME, AX, ISAXIS

```
Program code                                    Comment
OVRA[AXNAME("Transverse axis")]=10              ; Override for transverse axis
AX[AXNAME("Transverse axis")]=50.2              ; End position for transverse axis
OVRA[SPI(1)]=70                                 ; Override for spindle 1
AX[SPI(1)]=180                                  ; End position for spindle 1
IF ISAXIS(1) == FALSE GOTOF CONTINUE            ; Abscissa available?
AX[$P_AXN1]=100                                 ; Move abscissa
CONTINUE:
```

Example 2: AXSTRING

When programming with AXSTRING[SPI(n)], the axis index of the axis, which is assigned to the spindle, is no longer output as spindle number, but instead the string "Sn" is output.

Program code	Comment
AXSTRING[SPI(2)]	; String "S2" is output.

Example 3: MODAXVAL

The modulo position of modulo rotary axis A is to be determined.

Axis position 372.55 is the starting value for the calculation.

The parameterized modulo range is 0 to 360 degrees:

MD30340 MODULO_RANGE_START = 0

MD30330 $MA_MODULO_RANGE = 360

Program code	Comment
R10=MODAXVAL(A,372.55)	; Calculated modulo position R10 = 12.55.

Example 4: MODAXVAL

If the programmed axis identifier does not refer to a modulo rotary axis, then the value to be converted (<axis position>) is returned unchanged.

Program code	Comment
R11=MODAXVAL(X,372.55)	; X is a linear axis; R11 = 372.55.

16.2 Replaceable geometry axes (GEOAX)

Function

The "Replaceable geometry axes" function allows the geometry axis grouping configured via machine data to be modified from the part program. Here any geometry axis can be replaced by a channel axis defined as a synchronous special axis.

Syntax

```
GEOAX(<n>,<channel axis>,<n>,<channel axis>,<n>,<channel axis>)
GEOAX()
```

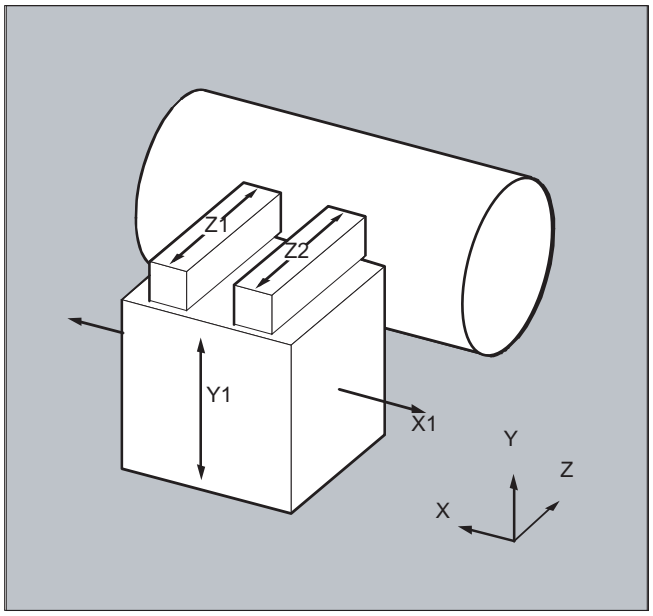
Meaning

`GEOAX(...)`	Command to change over (replace) the geometry axes **Note:** `GEOAX()` without any parameter calls the basic configuration of the geometry axes.
`<n>`	This parameter is used to specify the number of the geometry axis that should be assigned to the subsequently specified channel axis. Range of values: 1, 2, or 3 **Note:** With <n>=0, the subsequently specified channel axis can be completely removed – without any replacement – from the geometry axis group.
`<channel axis>`	The parameter is used to specify the name of the channel axis that should be included in the geometry axis group.

Examples

Example 1: Switching two axes alternating as geometry axis

A tool slide can be traversed using channel axes X1, Y1, Z1, Z2:



The geometry axes are configured so that after powering-up, initially Z1 is effective as 3rd geometry axis under the geometry axis name "Z" and together with X1 and Y1 forms the geometry axis group.

Axes Z1 an Z2 should now be used, alternating, as geometry axis Z in the part program:

```
Program code                    Comment
...
N100 GEOAX(3,Z2)                ; Channel axis Z2 acts as 3rd geometry axis (Z).
N110 G1 ...
N120 GEOAX(3,Z1)                ; Channel axis Z1 acts as 3rd geometry axis (Z).
...
```

Example 2: Changing over the geometry axes for 6 channel axes

A machine has 6 channel axes with the names XX, YY, ZZ, U, V, W.

The basic setting of the geometry axis configuration via machine data is:

Channel axis XX = 1st geometry axis (X axis)

Channel axis YY = 2nd geometry axis (Y axis)

Channel axis ZZ = 3rd geometry axis (Z axis)

```
Program code                    Comment
N10 GEOAX()                     ; The basic configuration of the geometry axes is
                                  effective.
N20 G0 X0 Y0 Z0 U0 V0 W0        ; All axes in rapid traverse to position 0.
N30 GEOAX(1,U,2,V,3,W)          ; Channel axis U becomes the first (X), V the second
                                  (Y) and W the third geometry axis (Z).
N40 GEOAX(1,XX,3,ZZ)            ; Channel axis XX becomes the first (X), ZZ the third
                                  geometry axis (Z). Channel axis V remains the
                                  second geometry (Y).
N50 G17 G2 X20 I10 F1000        ; Full circle in the X/Y plane. Channel axes XX and V
                                  traverse.
N60 GEOAX(2,W)                  ; Channel axis W becomes the second geometry (Y).
N80 G17 G2 X20 I10 F1000        ; Full circle in the X/Y plane. Channel axes XX and W
                                  traverse.
N90 GEOAX()                     ; Reset to the initial state.
N100 GEOAX(1,U,2,V,3,W)         ; Channel axis U becomes the first (X), V the second
                                  (Y) and W the third geometry axis (Z).
N110 G1 X10 Y10 Z10 XX=25       ; Channel axes U, V, W each traverse to position 10.
                                  XX as supplementary axis traverses to position 25.
N120 GEOAX(0,V)                 ; V is removed from the geometry axis group. U and W
                                  remain the first (X) and third geometry axis (Z).
                                  The second geometry (Y) axis remains unassigned.
N130 GEOAX(1,U,2,V,3,W)         ; Channel axis U remains the first (X), V becomes the
                                  second (Y), W remains the third geometry axis (Z).
N140 GEOAX(3,V)                 ; V becomes the third geometry axis (Z), whereby
                                  overwrite W and this is therefore taken out of the
                                  geometry axis group. The second geometry axis (Y)
                                  is, as before, unassigned.
```

Note

Axis configuration

The machine data below are used to assign the geometry axes, special axes, channel axes and machine axes as well as the names of the individual axis types:

MD20050 $MC_AXCONF_GEOAX_ASIGN_TAB (assignment of geometry axis to channel axis)

MD20060 $MC_AXCONF_GEOAX_NAME_TAB (name of the geometry axis in the channel)

MD20070 $MC_AXCONF_MACHAX_USED (machine axis number valid in channel)

MD20080 $MC_AXCONF_CHANAX_NAME_TAB (name of the channel axis in the channel)

MD10000 $MN_AXCONF_MACHAX_NAME_TAB (machine axis name)

MD35000 $MA_SPIND_ASSIGN_TO_MACHAX (assignment of spindle to machine axis)

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

Restrictions

- It is not possible to switch the geometry axes over during:
  - Active transformation
  - Active spline interpolation
  - Active tool radius compensation
  - Active fine tool compensation
- If the geometry axis and the channel axis have the same name, it is not possible to change the particular geometry axis.
- None of the axes involved in the changeover may be involved in an action that can go beyond the block limits – e.g.type A positioning axes or for following axes.
- Geometry axes can only be replaced using the command GEOAX if they were already available when the system was powered-up (this means that no new ones can be defined).
- An alarm is output if an attempt is made to replace an axis with GEOAX while executing the contour table (CONTPRON, CONTDCON).

Supplementary conditions

Axis state after replacing

An axis replaced by the changeover in the geometry axis group can be programmed as supplementary axis after the changeover operation via its channel axis names.

Frames, protection zones, working area limits

All frames, protection zones and working area limits are deleted after changing over the geometry axes.

Polar coordinates

Replacing the geometry axes with `GEOAX` sets analog to a level change with `G17`-`G19`, the modal polar coordinates to a value of 0.

DRF, ZO

A possible handwheel offset (DRF) or an external zero offset (ZO) remains effective after the changeover.

Basic configuration of the geometry axes

The `GEOAX()` command calls the basic configuration of the geometry axis group.

The system automatically changes back to the basic configuration after POWER ON and when changing over into the "reference point approach" mode.

Tool length compensation

An active tool length compensation is also effective after the changeover operation. However, for geometry axes that have been newly added or those where the position has been replaced, it is still considered not to have been moved through. For the first motion command for these geometry axes, the resulting traversing distance correspondingly comprises the sum of the tool length compensation and the programmed traversing distance.

Geometry axes, which retain their position in the axis group after a replacement operation, also retain their status with respect to tool length compensation.

Geometry axis configuration for active transformation

The geometry axis configuration applicable in an active transformation (defined using machine data) cannot be changed using the function "replaceable geometry axes".

Should it be necessary to modify the geometry axis configuration in conjunction with transformations, then this is only possible using an additional transformation.

A geometry axis configuration changed using `GEOAX` is deleted by activating a transformation.

If the machine data settings for the transformation do not match those for changing over geometry axes, then the settings in the transformation have priority.

Example:

One transformation active. According to the machine data, the transformation should be kept for a reset; however, at the same time, for a reset, the basic configuration of geometry axes should be established. In this particular case, the geometry axis configuration that was defined with the transformation is kept.

16.3 Axis container (AXCTSWE, AXCTSWED, AXCTSWEC)

Function

The AXCTSWE of AXCTSWED command is use to enable the rotation of the specified axis container.

An already set enable for axis container rotation is cancelled via the AXCTSWEC command.

Syntax

```
AXCTSWE(<ID>)
AXCTSWED(<ID>)
AXCTSWEC(<ID>)
```

Meaning

AXCTSWE: Enable for rotation of the axis container

The program processing is not stopped by AXCTSWE.

The rotation is performed as soon as all channels involved on the axis container have been enabled.

AXCTSWED: Enable to rotate the axis container without consideration of the other channels involved on the axis container

Note

- Command variant to simplify the commissioning of the part program or synchronized action.
- The behavior with regard to the other channels involved on axis container can be specified via:
  MD12760 $MN_ AXCT_FUNCTION_MASK, bit 0

AXCTSWEC: Canceling the enable to rotate the axis container

Note

Axis container rotation that has been enabled can only be cancelled if rotation has still not been started:

$AN_AXCTSWA[<axis container>] == 0

For system variable, see "Axis container (AXCTSWE, AXCTSWED, AXCTSWEC) (Page 590)"

<ID>: Identifier of the axis container or a container axis:

- CT<number>: Default identifier of an axis container:
  MD12750 $MN_AXCT_NAME_TAB
  Example: CT1
- <Container>: User-specific identifier of an axis container:
  MD12750 $MN_AXCT_NAME_TAB
  Example: CONTAINER_1
- <axis>: Identifier of a known container axis in the channel

Note

Increment

The increment of a axis container rotation is set via the setting data:

SD41700 $SN_AXCT_SWWIDTH

Further information

Diagnostics

The current status of a axis container can be read via the following system variables:

System variable	Type	Description
$AC_AXCTSWA[<name>]	BOOL	Channel-specific status of the axis container
$AN_AXCTSWA[<axis container>]	BOOL	NCU-specific status of the axis container
$AN_AXCTSWE[<axis container>]	INT	Slot-specific status of the axis container rotation The system variable supplies the status of the axis container slot **bitwise**. Each bit corresponds to a slot.
$AN_AXCTAS[<axis container>]	INT	Number of locations (slots) through which the axis container was just switched through.

Axis container rotation with implicit GET / GETD

The following machine data can be use to set that all container axes of the channel are brought into the channel by means of an implicit GET/GETD with the AXCTSWE command. An axis replacement is only possible again after the container rotation.

MD10722 $MN_AXCHANGE_MASK, bit 1 = 1

Note

An axis container rotation with implicit GET/GETD is **not** performed for an axis in the state "main run axis" (e.g. PLC axis) because the axis would have to exit the state for the axis container rotation.

16.4 Wait for valid axis position (WAITENC)

Function

Using the language command WAITENC, the NC program waits until the synchronized or restored axis positions are available for the axes configured with MD34800 $MA_WAIT_ENC_VALID = 1.

An interruption can take place in the wait state, e.g. by starting an ASUB or by changing the operating mode to JOG. When the program is continued, where relevant, the wait state is resumed.

Note

In the user interface, the wait state is displayed using the hold state "Wait for measuring system".

Syntax

WAITENC can be programmed in the program section of any NC program.

Programming must be realized in a dedicated block:

```
...
WAITENC
...
```

Example

WAITENC is e.g. used in an event-controlled user program, .../_N_CMA_DIR/_N_PROG_EVENT_SPF, as shown in the following application example.

Application example: Tool withdrawal after POWER OFF with orientation transformation

Machining with tool orientation was interrupted due to a power failure.
When powering up again, the event-controlled user program .../_N_CMA_DIR/_N_PROG_EVENT_SPF is called.

In the event-controlled user program, the system waits for synchronized or restored axis positions using WAITENC; in order to then be able to calculate a frame, which aligns the Work in the tool direction.

```
Program code                          Comment
...
IF $P_PROG_EVENT == 4                 ; Power-up
    IF $P_TRAFO <> 0                  ; Transformation has been selected.
        WAITENC                       ; Wait for valid axis positions of the orientation axes.
        TOROTZ                        ; Rotate the Z axis of the Work towards the tool axis.
```

```
Program code                                Comment
    ENDIF
    M17
ENDIF
...
```

The tool can then be retracted in JOG mode by means of a retraction movement towards the tool axis.

16.5 Programmable parameter set changeover (SCPARA)

Function

The changeover to a specific parameter set can be requested for an axis with the SCPARA command.

Note

No parameter set changeover during thread cutting

During thread cutting G33 and tapping G331/G332, the parameter set is selected by the controller and cannot be changed.

Disabled parameter set changeover

A parameter set changeover can also be requested via the NC/PLC interface. In order to avoid changeover conflicts, the parameter set changeover of the NC (SCPARA) can be disabled via the NC/PLC interface:

DB31, ... DBX9.3 (parameter set specification disabled by NC)

Note

If a parameter set changeover is requested by SCPARA while the parameter set changeover is disabled via the NC/PLC interface, the changeover is rejected without an error message.

Syntax

```
SCPARA[<axis>]=<value>
```

Meaning

SCPARA:	Command: Change parameter set
<axis>:	Axis identifier (channel axis)
	Type: AXIS
<value>:	Parameter set number: 1, 2, 3, ... max. parameter set number

Example

Program code	Comment
...	
N110 SCPARA[X]= 3	; Selection: Axis X, 3rd parameter set
...	

Further information

Enable of the parameter set changeover

The parameter set changeover of the axis must be explicitly enabled:

MD35590 $MA_PARAMSET_CHANGE_ENABLE[<axis>]

Read parameter set number

The number of the selected parameter set (specified parameter set) can be read via the system variable $AA_SCPAR.

References

Detailed information on the parameter sets can be found in:

Function Manual, Basic Functions; Section "Velocities, setpoint / actual value systems, closed-loop control (G2)" > "Closed-loop control" > "Parameter sets of the position controller"

16.6 Check scope of NC language present (STRINGIS)

Function

Using the function STRINGIS(...) it can be checked as to whether the specified string is available as element of the NC programming language in the actual language scope.

Definition

```
INT STRINGIS(STRING <Name>)
```

Syntax

```
STRINGIS(<Name>)
```

Meaning

STRINGIS:	Function with return value
<name>:	Name of the NC programming language element to be checked
Return value:	The return value format is yxx (decimal).

Elements of the NC programming language

The following elements of the NC programming language can be checked:

- G codes of all existing G function groups, e.g. G0, INVCW, POLY, ROT, KONT, SOFT, CUT2D, CDON, RMBBL, SPATH
- DIN or NC addresses, e.g. ADIS, RNDM, SPN, SR, MEAS
- Functions, e.g. TANG(...) or GETMDACT
- Procedures, e.g. SBLOF.
- Keywords, e.g. ACN, DEFINE or SETMS
- System data, e.g. machine data $M... , setting data $S... or option data $O...
- System variable $A... , $V..., $P...
- Arithmetic parameter R...
- Cycle names of activated cycles
- GUD and LUD variables
- Macro names
- Label names

Return value

Only the first three decimal positions of the return value are relevant. The return value format is yxx, with y = basis information and xx = detailed information.

Return value	Meaning
000	The 'name' string is not known in this system [1)]
100	The 'name' string is an element of the NC programming language, but currently cannot be programmed (option/function is inactive)

Return value	Meaning	
2xx	The 'name' string is a programmable element of the NC programming language (option/function is active). The detailed information xx contains additional information about the element type:	
	xx	**Meaning**
	01	DIN address or NC address[2)]
	02	G code (e.g. `G04`, `INVCW`)
	03	Function with return value
	04	Function without return value
	05	Keyword (e.g. `DEFINE`)
	06	Machine (`$M`...), setting (`$S`...) or option data (`$O`...)
	07	System parameters, e.g. system variable (`$`...) or arithmetic parameter (`R`...)
	08	Cycle (the cycle must be loaded into the NCK and the cycle program must be active [3)])
	09	GUD variable (the GUD variable must be defined in the GUD definition files and the GUD variables activated)
	10	Macro name (the macro must be defined in the macro definition files and macros activated) [4)]
	11	LUD variable of the actual part program
	12	ISO G code (ISO language mode must be active)
400	The 'name' string is an NC address, that was not identified as xx == 01 or xx == 10 and is not G or R [2)]	
y00	No specific assignment possible	

1) Depending on the control, under certain circumstances, only a subset of the Siemens NC language commands are known, e.g. SINUMERIK 802D sl. For these controls, for strings that are principally Siemens NC language commands, a value of 0 is returned. This behavior can be changed using MD10711 $MN_NC_LANGUAGE_CONFIGURATION. For MD10711 = 1, then a value of 100 is always returned for Siemens NC language commands.

2) NC addresses are the following letters: A, B, C, E, I, J, K, Q, U, V, W, X, Y, Z. These NC addresses can also be programmed with an address extension. The address extension can be specified when checking with STRINGIS.
Example: `201 == STRINGIS("A1").`
The letters: D, F, H, L, M, N, O, P, S, T are NC addresses or auxiliary functions that are defined by the user. A value of 400 is always returned for these. Example: 400 == STRINGIS("D"). These NC addresses cannot be specified with address extension when checking with STRINGIS.
Example: `000 == STRINGIS("M02")`, but `400 == STRINGIS("M").`

3) Names of cycle parameters cannot be checked with STRINGIS.
4) Address, defined as macro, e.g. G, H, M, L are identified as macro.

Examples

In the following examples it is assumed that the NC language elements specified as string - as long as nothing else is noted - can in principle be programmed in the control.

1. String "T" is defined as auxiliary function:

```
400 == STRINGIS("T")

000 == STRINGIS ("T3")
```

2. String "X" is defined as axis:

```
201 == STRINGIS("X")

201 == STRINGIS("X1")
```

3. String "A2" is defined as address with extension:

   ```
   201 == STRINGIS("A")
   ```

   ```
   201 == STRINGIS("A2")
   ```

4. String "INVCW" is defined as named G code:

   ```
   202 == STRINGIS("INVCW")
   ```

5. String "$MC_GCODE_RESET_VALUES" is defined as machine data:

   ```
   206 == STRINGIS("$MC_GCODE_RESET_VALUES")
   ```

6. String "GETMDACT" is an NC language function:

   ```
   203 == STRINGIS("GETMDACT ")
   ```

7. String "DEFINE" is a keyword:

   ```
   205 == STRINGIS("DEFINE")
   ```

8. String "$TC_DP3" is a system parameter (tool length component):

   ```
   207 == STRINGIS("$TC_DP3")
   ```

9. String "$TC_TP4" is a system parameter (tool size):

   ```
   207 == STRINGIS("$TC_TP4")
   ```

10. String "$TC_MPP4" is a system parameter (magazine location state):
    - Tool magazine management is active: `207 == STRINGIS("$TC_MPP4")` ;
    - Tool magazine management is not active: `000 == STRINGIS("$TC_MPP4")`

    Also refer to the paragraph below: Tool magazine management.

11. The string "MACHINERY_NAME" is defined as GUD variable:

    ```
    209 == STRINGIS("MACHINERY_NAME")
    ```

12. The "LONGMACRO" string is defined as macro:

    ```
    210 == STRINGIS("LONGMACRO")
    ```

13. The string "MYVAR" is defined as LUD variable:

    ```
    211 == STRINGIS("MYVAR")
    ```

14. String "XYZ" is a command that is not known in the NCK, GUD variable, macro or cycle name:

    ```
    000 == STRINGIS("XYZ")
    ```

Tool magazine management

If the tool magazine management function is not active, STRINGIS supplies for the system parameters of the tool magazine management, independent of the machine data

- MD10711 $MN_NC_LANGUAGE_CONFIGURATION

always a value of 000.

ISO mode

If the "ISO mode" function is active:

- MD18800 $MN_MM_EXTERN_LANGUAGE (activation, external NC languages)
- MD10880 $MN_ MM_EXTERN_CNC_SYSTEM (control system to be adapted)

STRINGIS checks the specified string initially as SINUMERIK G-Code. If the string is not a SINUMERIK G code, then it is subsequently checked as ISO G code.

Programmed switchovers (G290 (SINUMERIK mode), G291 (ISO Mode)) have no effect on STRINGIS.

Example

The machine data, relevant for the function STRINGIS(...), has the following values:

- MD10711 $MN_NC_LANGUAGE_CONFIGURATION = 2 (only the NC language commands whose options are set are considered to be known)
- MD19410 $ON_TRAFO_TYPE_MASK = 'H0' (option: transformations)
- MD10700 $MN_PREPROCESSING_LEVEL='H43' (preprocessing for cycles is active)

The following program example is executed without error message:

```
Program code                          Comment
N1 R1=STRINGIS("TRACYL")              ;   R1 == 0, as TRACYL is identified as
                                      ;   "not known" because of the missing transformation
                                      ;   option
N2 IF STRINGIS("TRACYL") == 204       ;
N3 TRACYL(1,2,3)                      ;   N3 is skipped
N4 ELSE
N5 G00                                ;   and instead, N5 is executed
N6 ENDIF
N7 M30
```

16.7 Interactively call the window from the part program (MMC)

Function

You can use the MMC command to display user-defined dialog windows (dialog displays) on the HMI from the part program.

The dialog window appearance is defined in a pure text configuration (COM file in cycles directory), while the HMI system software remains unchanged.

User-defined dialog windows cannot be called simultaneously in different channels.

Syntax

```
MMC(<command>,<acknowledgement mode>)
```

Meaning

`MMC`: Subprogram identifier

`<command>`: Parameter of the STRING type

Contains the MMC command, e.g. in the following form:

```
"CYCLES,PICTURE_ON,T_SK.COM,PICTURE,MGUD.DEF,PICTURE_3.AWB,TEST_1,A1"
```

- `CYCLES`: Operating area in which the configured user dialog boxes are implemented.
- `PICTURE_ON` or `PICTURE_OFF`: Command: Display selection or display deselection.
- `T_SK.COM`: Com file: Name of the dialog display file (user cycles). The dialog display design is defined here. The dialog screen is used to display user variables and/or comment texts.
- `PICTURE`: Name of dialog display: The individual displays are selected via the names of the dialog displays.
- `MGUD.DEF`: User data definition file, which is addressed while reading/writing variables.
- `PICTURE_3.AWB`: Graphics file
- `TEST_1`: Display time or acknowledgement variable.
- `A1`: Text variables...",

`<acknowledgement mode>`: Parameters of the type CHAR

Value:

- `"N"`: Without acknowledgement
  Program execution is continued when the command has been transmitted. The sender is not informed if the command cannot be executed successfully.
- `"S"`: Synchronous acknowledgement
  The program execution is paused until the receiving component acknowledges the command. If the acknowledgement is positive, the next command is executed. If the acknowledgement is negative, an error message is output.

"A":	Asynchronous acknowledgement The program execution is continued after the command is issued. The acknowledgement is stored in an acknowledgement variable (pre-defined system variable) and must be explicitly queried from the program. The parameter following the acknowledgement mode is the number of the acknowledgement variable.

If no <acknowledgement mode> has not been programmed, the synchronous acknowledgement is used as default setting.

16.8 Program runtime/part counter

16.8.1 Program runtime/part counter (overview)

Information on the program runtime and workpiece counter are provided to support the machine tool operator.

This information can be processed as system variables in the NC and/or PLC program. This information is also available to be displayed on the operator interface.

16.8.2 Program runtime

Function

The "program runtime" function provides internal NC timers to monitor technological processes, which can be read into the part program and into synchronized actions via the NC and channel-specific system variables.

The trigger for the runtime measurement ($AC_PROG_NET_TIME_TRIGGER) is the only system variable of the function that can be written to and is used to selectively measure program sections. This means that by writing the trigger into the NC program, the time measurement can be activated and deactivated.

System variable	Meaning	Activity
NC-specific		
$AN_SETUP_TIME	Time since the last control power up with default values ("cold restart") in minutes. Is automatically reset to "0" every time the control powers up with default values.	• Always active
$AN_POWERON_TIME	Time since the last normal control power up ("warm restart") in minutes. Is automatically reset to "0" every time the control powers up normally.	
Channel-specific		
$AC_OPERATING_TIME	Total runtime of NC programs in automatic mode in seconds. The value is automatically reset to "0" every time the control powers up.	• Activated via MD27860 • Only AUTOMATIC mode
$AC_CYCLE_TIME	Runtime of the selected NC program in seconds. The value is automatically reset to "0" every time a new NC program starts up.	
$AC_CUTTING_TIME	Processing time in seconds The runtime of the path axes (at least one is active) is measured in all NC programs between NC start and end of program/NC reset without rapid traverse active. The measurement is interrupted when a dwell time is active. The value is automatically reset to "0" every time the control powers up with default values.	
$AC_ACT_PROG_NET_TIME	Actual net runtime of the current NC program in seconds. Is automatically reset to "0" when a new NC program starts.	• Always active • Only AUTOMATIC mode
$AC_OLD_PROG_NET_TIME	Net runtime in seconds of the program that has just be correctly ended with `M30`	
$AC_OLD_PROG_NET_TIME_COUNT	Changes to $AC_OLD_PROG_NET_TIME After POWER ON, $AC_OLD_PROG_NET_TIME_COUNT is at "0". $AC_OLD_PROG_NET_TIME_COUNT is always increased if the control has newly written to $AC_OLD_PROG_NET_TIME.	

System variable	Meaning		Activity
$AC_PROG_NET_TIME_TRIGGER	Trigger for the runtime measurement:		• Only AUTOMATIC mode
	0	Neutral state The trigger is not active.	
	1	Exit Ends the measurement and copies the value from $AC_ACT_PROG_NET_TIME into $AC_OLD_PROG_NET_TIME. $AC_ACT_PROG_NET_TIME is set to "0" and then continues to run.	
	2	Start Starts the measurement and in so doing sets $AC_ACT_PROG_NET_TIME to "0". $AC_OLD_PROG_NET_TIME is not changed.	
	3	Stop Stops the measurement. Does not change $AC_OLD_PROG_NET_TIME and keeps $AC_ACT_PROG_NET_TIME constant until it resumes	
	4	Resume The measurement is resumed, i.e. a measurement that was previously stopped is continued. $AC_ACT_PROG_NET_TIME continues to run. $AC_OLD_PROG_NET_TIME is not changed.	
All system variables are reset to 0 as a result of POWER ON!			
Reference: A detailed description of the listed system variables is provided in: Function Manual, Basic Functions; Mode Group, Channel, Program Operation, Reset Response (K1), Chapter: Program runtime			

Note

Machine manufacturer

Machine data MD27860 $MC_PROCESSTIMER_MODE is used to switch-in the timer that can be activated.

The behavior of active time measurements for certain functions (e.g. GOTOS, override = 0%, active test run feed, program test, ASUB, PROG_EVENT, …) is configured using machine data MD27850 $MC_PROG_NET_TIMER_MODE and MD27860 $MC_PROCESSTIMER_MODE.

References:
Function Manual, Basic Functions; BAG, Channel, Program Operation, Reset Response (K1), Chapter: Program runtime

Note

Residual time for a workpiece

If the same workpieces are produced one after the other, then the timer values:

- Processing time for the last workpiece produced (see $AC_OLD_PROG_NET_TIME)

and

- Current processing time (see $AC_ACT_PROG_NET_TIME)

can be used to determine the remaining residual time for a workpiece.

The residual time is displayed on the operator interface in addition to the current processing time.

Note

Using STOPRE

The system variables $AC_OLD_PROG_NET_TIME and $AC_OLD_PROG_NET_TIME_COUNT do not generate any implicit preprocessing stop. This is uncritical when used in the part program if the value of the system variables comes from the previous program run. However, if the trigger for the runtime measurement ($AC_PROG_NET_TIME_TRIGGER) is written very frequently and as a result $AC_OLD_PROG_NET_TIME changes very frequently, then an explicit `STOPRE` should be used in the part program.

General conditions

- **Block search**

  No program runtimes are determined through block searches.

- **REPOS**

  The duration of a REPOS process is added to the current processing time ($AC_ACT_PROG_NET_TIME).

Examples

Example 1: Measuring the duration of "mySubProgrammA"

Program code

```
...
N50 DO $AC_PROG_NET_TIME_TRIGGER=2
N60 FOR ii= 0 TO 300
N70 mySubProgrammA
N80 DO $AC_PROG_NET_TIME_TRIGGER=1
N95 ENDFOR
N97 mySubProgrammB
N98 M30
```

After the program has processed line N80, the net runtime of "mySubProgrammA" is located in $AC_OLD_PROG_NET_TIME.

The value from $AC_OLD_PROG_NET_TIME:

- is kept beyond M30.
- is updated each time the loop is run through.

Example 2: Measuring the duration of "mySubProgrammA" and "mySubProgrammC"

Program code

```
...
N10 DO $AC_PROG_NET_TIME_TRIGGER=2
N20 mySubProgrammA
N30 DO $AC_PROG_NET_TIME_TRIGGER=3
N40 mySubProgrammB
N50 DO $AC_PROG_NET_TIME_TRIGGER=4
N60 mySubProgrammC
N70 DO $AC_PROG_NET_TIME_TRIGGER=1
N80 mySubProgrammD
N90 M30
```

16.8.3 Workpiece counter

Function

The "Workpiece counter" function makes available various counters which can be used in particular internally in the controller to count workpieces.

The counters exist as channel-specific system variables with read and write access in a range of values from 0 to 999 999 999.

System variable	Meaning
$AC_REQUIRED_PARTS	Number of workpieces to be produced (setpoint number of workpieces) In this counter the number of workpieces at which the actual workpiece count ($AC_ACTUAL_PARTS) will be reset to "0" can be defined.
$AC_TOTAL_PARTS	Total number of completed workpieces (actual workpiece total) This counter specifies the total number of all workpieces produced since the start time. The value is only automatically reset to "0" when the controller powers up with default values.

System variable	Meaning
$AC_ACTUAL_PARTS	Number of completed workpieces (actual workpiece total) This counter registers the total number of all workpieces produced since the start time. On condition that $AC_REQUIRED_PARTS > 0, the counter is automatically reset to "0" when the required number of workpieces ($AC_REQUIRED_PARTS) is reached.
$AC_SPECIAL_PARTS	Number of workpieces selected by the user This counter supports user-specific workpiece counts. An alarm can be defined to be output when the setpoint number of workpieces is reached ($AC_REQUIRED_PARTS). Users must reset the counter themselves.

Note

All workpiece counters are set to "0" when the controller powers up with default values and can be read and written independent of their activation.

Note

Channel-specific machine data can be used to control counter activation, counter reset timing and the counting algorithm.

Note

Workpiece counting with user-defined M command

Machine data can be set so that the count pulses for the various workpiece counters are triggered using user-defined M commands rather than the end of the program (M2/M30).

References

For further information about the "Workpiece counter" function see:

- Function Manual, Basic Functions; Mode Group, Channel, Program Operation, Reset Response (K1), Section: Workpiece counter

16.9 Process DataShare - output to an external device/file (EXTOPEN, WRITE, EXTCLOSE)

Function

With the "Process DataShare" function, it is possible to write data from a part program to an external device / an external file; for instance, to log production data or to control additional equipment at a control system.

Output to an external device/file is realized in three steps:

1. Open the external device/file

   The external device/file is opened for the channel for writing using the EXTOPEN command.

2. Writing data

   The output date can be processed using the string functions of the NC language ("String operations (Page 78)"), e.g. SPRINT. The WRITE command is used for writing.

3. Close the external device/file

   The external device/file assigned in the channel is released again using the EXTCLOSE command, when the end of the program is reached (M30) or for a channel reset.

Note

More than one external device/file can also be assigned in a part program/channel.

Availability

This function is available:

- Only in part programs (**not** in synchronized actions).
- Parallel in all machining channels of the NCK for all available (configured) output devices.

For each output device, when opening the device, it can be specified as to whether the device is to be exclusively used by just one channel or whether several channels can output to the device ("shared" mode).

Syntax

```
DEF INT <error>
DEF STRING[<n>] <output>
…
EXTOPEN(<error>,"<ExtG>",<machining mode>,<usage mode>,
<write mode>)
…
<output>="output data"
WRITE(<error>,"<ExtG>",<output>)
…
EXTCLOSE(<error>,"<ExtG>")
```

Meaning

`EXTOPEN`: Command to open an external device/file

`<error>`: **Parameter 1:** Variable for returning the error value

By using the error value, it can be evaluated in the program as to whether the operation was successful and processing is then appropriately continued.

Type: INT

Values:
- 0 No error
- 1 External device cannot be opened
- 2 External device is not configured
- 3 External device with invalid path configured
- 4 No access rights for external device
- 5 Usage mode: External device already "exclusively" occupied
- 6 Usage mode: External device already being "shared"
- 7 File length longer than LOCAL_DRIVE_MAX_FILESIZE
- 8 Maximum number of external devices has been exceeded
- 9 Option for LOCAL_DRIVE not set
- 11 V.24 interface has already been assigned with Easy-Message function (only 828D)
- 12 Write mode: Data contradicts extdev.ini
- 16 Invalid external path has been programmed
- 22 External device not mounted

`<ExtG>`: **Parameter 2:** Symbolic identifier for the external device/file to be opened

Type: STRING

The symbolic identifier comprises:

1. the logical device name
2. where relevant, followed by a file path (attached using "/").

The following **logical device names** have been defined:

`"LOCAL_DRIVE"`: Local CompactFlash card (pre-defined)

"CYC_DRIVE":	Reserved drive name for use in SIEMENS cycles (pre-defined)
"/dev/ext/1",... "/dev/ext/9":	Available network drives **Note:** It is necessary to configure in the extdev.ini file!
"/dev/cyc/1", "/dev/cyc/2":	Reserved drive names for use in SIEMENS cycles **Note:** It is necessary to configure in the extdev.ini file!
"/dev/v24":	V.24 interface **Note:** It is necessary to configure in the extdev.ini file!

File path:

- A file path must be specified for "LOCAL_DRIVE" and "CYC_DRIVE" e.g.:

  "LOCAL_DRIVE/my_dir/my_file.txt"
- The logical device names "/dev/ext/1...9" and "/dev/cyc/1...2" can be configured:
  - To already refer to a file, in which case only the logical device names may be specified, e.g.:

    "/dev/ext/4"
  - Or to a directory, in which case, a file path must be specified, e.g.:

    "/dev/ext/5/my_dir/my_file.txt"
- It is not permissible that a file path is attached to "/dev/v24".

Note:
For the logical device names "/dev/ext/1...9", "/dev/v24" and "/dev/cyc/1...2" upper case/lower case is ignored; upper case/lower case is significant for specifying a path to a file. Only uppercase letters are permissible for "LOCAL_DRIVE" and "CYC_DRIVE".

<processing mode>: **Parameter 3:** Processing mode for the WRITE commands to this device/file

Type: STRING

Values: "SYN": Synchronous writing

Program execution is stopped until the write operation has been completed.

Successfully completing the synchronous write operation can be checked by evaluating the error variables of the WRITE command.

"ASYN": Asynchronous writing

Program execution is not interrupted by the WRITE command.

Note:
In this mode, the error variable of the WRITE command does not provide any information and always has the value 0 (no error). In this particular mode, there is no certainty that the WRITE command was successful.

<usage mode>: **Parameter 4:** Usage mode for this device/file

Type: STRING

Values: "SHARED": Device/file is requested in the "shared" mode. Other channels can also use the device, i.e. also open in this mode.

"EXCL": Device/file is exclusively used in the channel; no other channel can use the device.

<write mode>: **Parameter 5:** Write mode for the WRITE commands to this file/device (optional)

Type: STRING

Values: "APP": Attaching

The file is always kept regarding its contents; write calls are attached at the end.

"OVR": Overwrite

The contents of the file are deleted and re-generated using the subsequent write calls.

Note:
Using this parameter, the write mode configured in the extdev.ini file **cannot** be overwritten. In the case of a conflict, then the EXTOPEN call is acknowledged with error.

WRITE: Command to write output data

For a description, see "Write file (WRITE) (Page 139)"!

EXTCLOSE: Command to close an external device/file that has been opened

<error>: **Parameter 1:** Variable for returning the error value

Type: INT

Values: 0 No error

16 Invalid external path has been programmed

21 Error when closing the external device

<ExtG>: **Parameter 2:** Symbolic identifier for the external device/file to be closed

For a description see under EXTOPEN!

Note:
The identifier must be identical to the identifier specified in the EXTOPEN command!

Example

Program code

```
N10    DEF INT RESULT
N20    DEF BOOL EXTDEVICE
N30    DEF STRING[80] OUTPUT
N40    DEF INT PHASE
N50    EXTOPEN(RESULT,"LOCAL_DRIVE/my_file.txt","SYN","SHARED")
N60    IF RESULT > 0
N70      MSG("error for EXTOPEN:" << RESULT)
N80    ELSE
N90      EXTDEVICE=TRUE
N100   ENDIF
…
N200   PHASE=4
N210   IF EXTDEVICE
N220     OUTPUT=SPRINT("end of phase: %D",PHASE)
N230     WRITE(RESULT,"LOCAL_DRIVE/my_file.txt",OUTPUT)
N240   ENDIF
…
```

Further information

Effect on continuous path mode

The EXTOPEN, WRITE and EXTCLOSE commands trigger a preprocessing stop and therefore interrupt the continuous path mode.

Block-search behavior

During "block search with calculation" with WRITE, no output is made. However, the EXTOPEN and EXTCLOSEcommands are collected and set active with NC start after the search target was reached. The following WRITE commands therefore find the same environment as for the normal program processing.

For a search with calculation in the "Program test" mode (SERUPRO), EXTOPEN, WRITE and EXTCLOSE are executed just the same as for normal program processing.

Reset behavior

With part program end and channel reset, all of the external devices/files that have been opened in this channel are closed.

Available external devices

The following can be used as external devices/files:

- Files on the local CompactFlash Card

  Local CompactFlash Card means the memory that is referred to from the HMI using the symbolic identifier LOCAL_DRIVE. For SINUMERIK 840D sl this is the local drive, for SINUMERIK 828D, the user CompactFlash Card.

  Note

  For SINUMERIK 840D sl, the option "Additional xxx MB HMI user memory on CF card of the NCU" is required for output to the LOCAL_DRIVE device. For SINUMERIK 828D a user CompactFlash Card must be available and an option is not required here.

- Files on a network drive
- V.24 interface

  Note

  For SINUMERIK 840D sl, the NCU option module RS232 interface is required for output at the V.24 interface. For SINUMERIK 828D output is realized at the integrated V.24 interface (precondition: MD51233 $MNS_ENABLE_GSM_MODEM = 0).

Configuration

The external devices to be used are configured in the file /oem/sinumerik/nck/extdev.ini or /user/sinumerik/nck/extdev.ini. If both files are available, then the entries in the user area have priority. The file can be updated in the operating area COMMISSIONING under SYSTEMDATEN/CF card.

Note

It is not necessary to configure in the extdev.ini file when using LOCAL_DRIVE and CYC_DRIVE. The two devices are always available as soon as the corresponding option is set or the user CompactFlash Card is available.

The external devices to be used are defined/listed in the section [ExternalDevices] of the extdev.ini file. A serial device (/dev/v24) and up to nine files or directories (/dev/ext/1…9) can be specified as device. The Linux notation is used when specifying devices. Lines, which start with ";", are comments and are overread.

With the exception of /dev/v24, the devices can be declared as directory path - terminated with an attached "/" – or as file path – i.e. with attached fully qualified path, ending with a filename (without a terminating "/"). When used in a part program, a file name (path) must also be specified for a device with directory path.

With the exception for /dev/v24, a device is defined using the three data separated by a comma for "Server", "Path" and the optional "Write mode".

For the files or directories (this then applies to all files in the directory), it can be specified as to whether the file should be overwritten after it has been opened ("O" = Overwrite) or whether the outputs should be attached to the file ("A" = Append). The default value is "A". A file/directory that does not exist is newly created when opening.

For the device V.24 interface, only the settings for baud rate, data bits, stop bits, parity, protocol and possibly end are specified in this sequence.

For files that are generated/saved on the LOCAL_DRIVE, LOCAL_DRIVE_MAX_FILESIZE data can be used to set a maximum file size in bytes - this is then valid as standard for all files. The file size is checked when executing an `EXTOPEN` command in the Append mode. Optionally, the write mode ("O" = Overwrite, "A" = Append) can be defined using the LOCAL_DRIVE_FILE_MODE data. The default value is "A".

Note

A copy template for the extdev.ini configuration file is available in directory /siemens/sinumerik/nck.

Note

Changes to the extdev.ini file only become effective after an NCK restart/boot.

Note

USB devices

For SINUMERIK 828D, "usb" (without partition data!) can also be defined as target for a USB device inserted at the front. The device at the USB can be addressed from the part program only directly using a symbolic device identifier `"/dev/ext/x"`.

For SINUMERIK 840D sl, only statically connected USB interfaces of a TCU can be configured as USB devices. The configuration is realized using the SERVER:/PATH type as specification for "Server" in the sense above, whereby SERVER is the TCU name and /PATH designates the USB interface. The USB interfaces of a TCU are addressed using "dev0-0", "dev0-1", "dev1-0". The path data always starts with "/Partition", whereby the partition can be specified using a two-digit partition number or its partition name – and where required, is extended with a file path up to the required target, e.g.:

/dev/ext/8 = "TCU4:/dev0-0, /01/, A"

/dev/ext/8 = "TCU4:/dev0-0, /01/mydir.dir/"

/dev/ext/8 = "TCU4:/dev0-0, /myfirstpartition/Mydir.dir/myfile.txt, O"

Examples:

```
[ExternalDevices]
; Comment line
; example for V24
; /dev/v24 = "9600, 8, 1, none, rts [, etx]"
; examples for network drives
; /dev/ext/1 = "//[USERNAME[/DOMAIN][%PASSWORD]@]SERVER/SHARE/, /, A"
; /dev/ext/2 = "//[USERNAME[/DOMAIN][%PASSWORD]@]SERVER/SHARE, /myfile.txt, O"
; /dev/ext/3 = "//[USERNAME[/DOMAIN][%PASSWORD]@]SERVER/SHARE, /mydir/, A"
; /dev/ext/4 = "SERVER:/dev0-0, /01/, A"
; …
; SINUMERIK 828 only (USB)
; /dev/ext/9 = "usb, / [ , O]"
; default: Partition number = 1

; SIEMENS only
; /dev/cyc/1= "//[USERNAME[/DOMAIN][%PASSWORD]@]SERVER/SHARE, /mydir/, A"
; /dev/cyc/2= "//[USERNAME[/DOMAIN][%PASSWORD]@]SERVER/SHARE/mydir, /, A"

LOCAL_DRIVE_MAX_FILESIZE = 50000
LOCAL_DRIVE_FILE_MODE = "O"
```

Effectiveness of the EXTOPEN parameter <write mode>

By specifying the write mode, when configuring in the extdev.ini file as well as for an EXTOPEN call, authorization conflicts can occur, which are then acknowledged with EXTOPEN - possibly with error:

Value from extdev.ini	Value of the EXTOPEN parameter		
	"OVR"	"APP"	-
"O"	O	Error	O
"A"	Error	A	A
-	O	A	A
	Explanation: O: "Overwrite" mode is active. A: "Append" mode is active. Error: EXTOPEN call is acknowledged with error.		

LOCAL_DRIVE: File attribute

The files created with EXTOPEN on LOCAL_DRIVE are allocated the following file attributes:

- Owner: "user" Read/write rights set
- Group: "operator" Read/write rights set

Maximum number of opened external devices

A maximum of 10 output devices can be simultaneously opened across all NC channels. In addition, there are two entries reserved for Siemens cycles.

A maximum of 5 tasks can be simultaneously active for these devices.

16.10 Alarms (SETAL)

Function

Alarms can be set in an NC program. Alarms are displayed in a separate field at the operator interface. An alarm always goes hand in hand with a response from the controller according to the alarm category.

References:
Further information on alarm responses, refer to the Commissioning Manual.

Syntax

```
SETAL(<alarm number>[,<character string>])
```

Meaning

SETAL:	Keyword to program an alarm. SETAL must be programmed in a separate NC block.
<alarm number>:	Type INT variable. Contains the alarm number. The valid range for alarm numbers lies between 60000 and 69999, of which 60000 to 64999 are reserved for SIEMENS cycles and 65000 to 69999 are available to users.
<character string>:	When programming user cycle alarms, in addition, a character string with up to 4 parameters can be specified. Variable user texts can be defined in these parameters. However, the following predefined parameters are available:

Parameter	Meaning
%1	Channel number
%2	Block number, label
%3	Text index for cycle alarms
%4	Additional alarm parameters

Note

Alarm texts must be configured in the operator interface.

Note

If an alarm is to be output in the language active at the user interface, then the user requires information about the language that is currently set at the HMI. This information can be interrogated in the part program and in the synchronized actions using system variable $AN_LANGUAGE_ON_HMI (see "Currently set language in the HMI (Page 802)").

Example

```
Program code                          Comment
...
N100 SETAL (65000)                    ; Setting alarm no. 65000
...
```

16.11 Extended stop and retract (ESR)

Function

The extended stop and retract function - subsequently called ESR - offers the possibility of flexibly responding when a fault situation occurs as a function of the process:

- **Extended stop**

  Assuming that the specific fault situation permits it, all of the axes, enabled for extended stopping, are stopped in an orderly fashion.

- **Retraction**

  The tool currently in use is retracted from the workpiece as quickly as possible.

- **Generator operation (SINAMICS drive function "Vdc control")**

  If a parameterizable value of the DC link voltage is fallen below, e.g. because the line voltage fails, the electrical energy required for retraction is generated by recovering the braking energy of the drive intended for this purpose (generator operation).

Trigger sources

General sources (NC-external/global or mode group-/channel-specific):

- Digital inputs (e.g. on NCU module or the controller-internal digital output image that can be read back ($A_IN, $A_OUT)
- Channel state ($AC_STAT)
- VDI signals ($A_DBB)
- Group messages of a number of alarms ($AC_ALARM_STAT)

Axial sources

- Emergency retraction threshold of the following axis (synchronism of electronic coupling, $VA_EG_SYNCDIFF[<following axis>])
- Drive: DC link warning threshold (imminent undervoltage), $AA_ESR_STAT[<axis>]
- Drive: Generator minimum speed threshold (no further regenerative rotation energy available), $AA_ESR_STAT[<axis>].

Gating logic of the static synchronized actions: Source/response link

The static synchronized actions' flexible gating possibilities are used to trigger specific reactions relatively quickly according to the sources.

Linking all relevant sources using static synchronized actions is the responsibility of the user. They can selectively evaluate the source system variables as a whole or by means of bit masks, and then make a logic operation with their desired reactions. The static synchronous actions are effective in all operating modes.

References:
Function Manual, Synchronized Actions

Activation

Function enable

The functions generator operation, shutdown, retraction are released by setting the corresponding control signal $AA_ESR_ENABLE. This control signal can be changed by synchronized actions.

Function triggering

ESR is triggered jointly for all enabled axes by setting the system variable $AC_ESR_TRIGGER.

Generator operation is "automatically" activated in the drive when an imminent DC link undervoltage is detected.

Drive-independent stopping and/or retraction become active when a communication failure (between the NC and drive) is detected and when a DC link undervoltage is detected in the drive (configuration and enable required).

Drive-independent stopping and/or retraction can also be triggered by the NC by setting the appropriate control signal $AN_ESR_TRIGGER (broadcast command to all drives).

References

For detailed information on ESR, see:

Function Manual, Special Functions; Extended Stop and Retract (R3)

16.11.1 NC-controlled ESR

16.11.1.1 NC-controlled retraction (POLF, POLFA, POLFMASK, POLFMLIN)

Function

Certain initial conditions are required for NC-controlled retraction (see "NC-controlled retraction (POLF, POLFA, POLFMASK, POLFMLIN) (Page 617)"). When these requirements have been satisfied, then the rapid lift (LIFTFAST) configured for retraction axis(axes) in the channel is activated by setting the system variable $AC_ESR_TRIGGER (or $AA_ESR_TRIGGER for single axes).

Syntax

```
POLF(<axis>)=<position>
POLFA(<axis>,<type>,<position>)
POLFMASK(<axis_1>,<axis_2>,...)
POLFMLIN(<axis_1>,<axis_2>,...)
```

The following abbreviated forms are permitted for POLFA:

```
POLFA(<axis>,<type>) ; Abbreviated form for single axis retraction
POLFA(axis,0/1/2) ; Quick deactivation or activation
POLFA(axis,0,$AA_POLFA[axis]) ; Causes a preprocessing stop
POLFA(axis,0) ; Does not cause a preprocessing stop
```

Meaning

POLF: Address for specifying the target position of the retraction axis

POLF is modal.

<axis>: Name of the geometry or channel/machine axis that retracts

<position>: Retraction position

Type: REAL

WCS is valid for geometry axes, otherwise MCS.
With the same identifiers for geometry and channel/machine axes, retraction is in the WCS.

POLFA: Predefined subprogram call for the specification of the retraction position of single axes

<axis>: Channel axis identifier

<type>: Position specification mode

Type: INT

Value: 0: Mark position value as invalid

1: Position value is absolute

2: Position value is incremental (distance)

Note:
If an axis is not a single axis or if the type is missing or type=0, then a corresponding alarm is output.

<position>: Retraction position (see above)

Note:
The position value is also accepted with type=0. Only this value is marked as invalid and has to be reprogrammed for retraction.

POLFMASK: Predefined subprogram call for selection of the axes that are to be retracted after tripping of rapid lift **independently of one another**.

<axis_1>,…: Names of the axes that are to be traversed to their positions defined with POLF during rapid lift.

All the axes specified must be in the same coordinate system.

POLFMASK() without specification of an axis deactivates the rapid lift for all axes that have been retracted independently of one another.

POLFMLIN: Predefined subprogram call for selection of the axes that are to be retracted after tripping of rapid lift **in linear relation**.

<axis_1>,…: See above.

POLFMLIN() without specification of an axis deactivates the rapid lift for all axes that have been retracted in linear relation.

Note

Before rapid retraction to a fixed position can be enabled via POLFMASK or POLFMLIN a position must have been programmed with POLF for the selected axes.

Note

If axes are enabled one after the other with POLFMASK, POLFMLIN or POLFMLIN, POLFMASK, then the last definition always applies for the particular axis.

Note

The positions programmed with POLF and the activation by POLFMASK or POLFMLIN are deleted when the part program is started. This means that the user must reprogram the values for POLF and the selected axes in POLFMASK or POLFMLIN in each part program.

Note

If, when using the abbreviated form POLFA only the type is changed, then the user must ensure that either the retraction position or the retraction path contains a practical and sensible value. In particular, the retraction position and the retraction path have to be set again after Power On.

Example

Retracting an individual axis:

Program code	Comment
MD37500 $MA_ESR_REACTION[AX1]=21	; NC-controlled retraction.
...	
$AA_ESR_ENABLE[AX1]=1	
POLFA(AX1,1,20.0)	; AX1 is assigned the axial retraction position 20.0 (absolute).
$AA_ESR_TRIGGER[AX1]=1	; Retraction starts from here.

Further information

Requirements for NC-controlled retraction

- A retraction axis is configured for the NC-controlled retraction in the channel:

  MD37500 $MA_ESR_REACTION = 21
- ESR must be must be enabled for this axis:

  $AA_ESR_ENABLE = 1
- Delay times are defined:

  MD21380 $MC_ESR_DELAY_TIME1

  MD21381 $MC_ESR_DELAY_TIME2
- The axis-specific retraction positions have been configured with POLF in the part program.
- The axes are selected with POLFMASK/POLFMLIN for the NC-controlled retraction.
- The activate signals must be set for the retraction movement and remain set.

Enable and start NC-controlled reactions

If system variable $AC_ESR_TRIGGER = 1 is set and if a retraction axis is configured in this channel (i.e. MD37500 $MA_ESR_REACTION = 21) and $AA_ESR_ENABLE = 1 is set for this axis, then rapid lift (LIFTFAST) is activated in this channel.

The lift movement configured with POLF (or POLF) for the axes selected with POLFMASK or POLFMLIN replaces the path motion defined for these axes in the part program.

The sum of the MD21380 $MC_ESR_DELAY_TIME1 and MD21381 $MC_ESR_DELAY_TIME2 times is the maximum available for the retraction. When this time has expired, rapid deceleration with follow-up is also initiated for the retraction axis.

Note

The extended retraction (i.e. LIFTFAST/LFPOS triggered by $AC_ESR_TRIGGER) **cannot be interrupted** and can only be terminated prematurely via an emergency stop.

Note

Retraction initiated via $AC_ESR_TRIGGER is locked, in order to prevent multiple retractions.

Single axis retraction

With single axis retraction, the retraction position of the single axis must have been programmed with `POLFA` and the following conditions must be satisfied:

- $AA_ESR_ENABLE = 1
- <Axis> must be a single axis at the time of triggering ($AAAA_ESR_TRIGGER = 1).
- <Type> must be either 1 or 2.

Retraction direction during rapid lift

The frame valid at the time when the lift fast is activated is taken into consideration.

Note

Frames with rotation also affect the direction of lift via `POLF`.

Axis replacement

Retraction axes must always be assigned to exactly one NC channel and may not be switched among the channels. When an attempt is made to exchange a retraction axis in another channel, an alarm is output. Only once this axis has been deactivated again using $AA_ESR_ENABLE[AX] = 0 can it be exchanged in a new channel. Once the axis has been exchanged, axes can be acted upon again with $AA_ESR_ENABLE[AX] = 1.

Neutral axes

Neutral axes cannot undertake NC-controlled ESR.

16.11.1.2 NC-controlled stopping

Function

The NC-controlled stopping is activated for the stopping axes configured in the channel by setting system variable $AC_ESR_TRIGGER (or $AA_ESR_TRIGGER for single axes).

Requirements

- A stopping axis is configured for the NC-controlled stopping in the channel:
  MD37500 $MA_ESR_REACTION = 22
- ESR must be must be enabled for this axis:
  $AA_ESR_ENABLE = 1
- Delay times are defined:
  MD21380 $MC_ESR_DELAY_TIME1 (delay time, ESR axes)
  MD21381 $MC_ESR_DELAY_TIME2 (ESR time for interpolatory braking)

Outlet

This axis continues interpolating as programmed for the time duration set in MD21380: After the time delay specified in MD21380 has expired, controlled braking (ramp stop) is initiated: The time period in MD21381 is the maximum available for the interpolatory controlled braking. After this period expires, fast braking with subsequent tracking is initiated.

Example

Stopping a single axis:

```
Program code                                        Comment
MD37500 $MC_ESR_REACTION[AX1] = 22                  ;   NC-controlled stopping.
MD21380 $MC_ESR_DELAY_TIME1[AX1] = 0.3
MD21381 $MC_ESR_DELAY_TIME2[AX1] = 0.06
...
$AA_ESR_ENABLE[AX1]=1
$AA_ESR_TRIGGER[AX1]=1                              ;  Stopping starts from here.
```

16.11.2 Drive-integrated ESR

16.11.2.1 Configuring drive-integrated stopping (ESRS)

Function

The drive parameters for "stopping" of the drive-integrated ESR function are configured using the `ESRS(...)` function.

Syntax

```
ESRS(<access_1>,<stopping time_1>[,...,<axis_n>,<stopping time_n>])
```

Meaning

`ESRS(...)`:	Function to write to the drive parameters for the ESR function "stopping" The function: • Must be alone in the block. • Triggers a preprocessing stop. • Cannot be used in synchronized actions.
`<axis_1>, ..., <axis_n>`:	Axis for which drive-integrated stopping should be configured For this axis, drive parameter p0888 (configuration) is written to in the drive: p0888 = 1 Type: AXIS Range of values: Channel axis identifier
`<stopping time_1>, ..., <stopping time_n>`:	Time during which the drive continues to travel with the actual speed setpoint after a fault has occurred For the specified axis, drive parameter p0892 (timer) is written to in the drive: p0892 = <stopping time> Unit: s Type: REAL Range of values: 0.00 - 20.00

A maximum of 5 axes can be programmed in a function call; n = 5

16.11.2.2 Configuring drive-integrated retraction (ESRS)

Function

The drive parameters for "retraction" of the drive-integrated ESR function are configured using the `ESRR(...)` function.

Syntax

```
ESRR(<axis_1>,<retraction distance_1>,<retraction
velocity_1>[,...,<axis_n>,<retraction distance_n>,<retraction velocity_n>])
```

Meaning

`ESRR(...)`: Function to write to the drive parameters for the ESR function "retract"

The function:

- Must be alone in the block.
- Triggers a preprocessing stop.
- Cannot be used in synchronized actions.

`<axis_1>, ..., <axis_n>`: Axis for which drive-integrated retraction should be configured

For this axis, drive parameter p0888 (configuration) is written to in the drive:

p0888 = 2

Type: AXIS

Range of values: Channel axis identifier

`<retraction distance_1>, ..., <retraction distance_n>`: For the drive, the retraction distance is converted into a retraction speed. For the specified axis, the value is written to drive parameter p0893 (speed):

p0893 = (<retraction distance _n> converted into retraction speed)

Unit: mm/min, inch/min, degrees/min (depending on the unit of the axis)

Type: REAL

Range of values: MIN - MAX

`<retraction velocity_1>, ..., <retraction velocity_n>`: For the drive, the retraction velocity is converted into a time. For the specified axis, the value is written to drive parameter p0892 (timer) [s]:

p0892 = <retraction distance_n> / <retraction velocity _n>

Unit: mm/min, inch/min, degrees/min (depending on the unit of the axis)

Type: REAL

Range of values: 0.00 - MAX

A maximum of 5 axes can be programmed in a function call; n = 5

User stock removal programs 17

17.1 Supporting functions for stock removal

Functions

Preprogrammed stock removal programs are provided for stock removal. Beyond this, you have the possibility of generating your own stock removal programs using the following listed functions:

- Generate contour table (CONTPRON)
- Generate coded contour table (CONTDCON)
- Deactivate contour preparation (EXECUTE)
- Determine point of intersection between two contour elements (INTERSEC)

  (Only for tables that were generated using CONTPRON)
- Executing contour elements of a table block-by-block (EXECTAB)

  (Only for tables that were generated using CONTPRON)
- Calculate circle data (CALCDAT)

Note

You can use these functions universally, not just for stock removal.

Requirements

The following must be done before calling the CONTPRON or CONTDCON functions:

- A starting point that permits collision-free machining must be approached.
- The cutting radius compensation must be deactivated with `G40`.

17.2 Generate contour table (CONTPRON)

Function

Contour preparation is activated using the command CONTPRON. The NC blocks that are subsequently called are not executed, but are split-up into individual movements and stored in the contour table. Each contour element corresponds to one row in the two-dimensional array of the contour table. The number of relief cuts is returned.

Syntax

Activate contour preparation:
```
CONTPRON(<contour table>,<machining type>,<relief cuts>,
<machining direction>)
```

Deactivate contour preparation and return to the normal execution mode:
```
EXECUTE(<ERROR>)
```

See "Deactivate contour preparation (EXECUTE) (Page 640)"

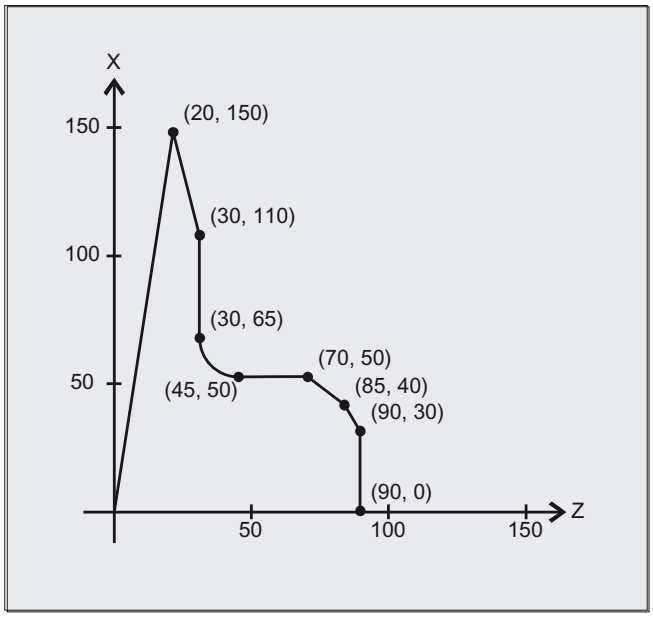
Meaning

CONTPRON	Command to activate contour preparation to generate a contour table		
<contour table>	Names of contour table		
<machining type>	Parameter for the machining type		
	Type:	CHAR	
	Value:	"G"	Longitudinal turning: Inside machining
		"L"	Longitudinal turning: External machining
		"N"	Face turning: Inside machining
		"P"	Face turning: External machining
<relief cuts>	Result variable for the number of relief cut elements that occur		
	Type:	INT	
<machining direction>	Parameters for the machining direction		
	Type:	INT	
	Value:	0	Contour preparation, forwards (default value)
		1	Contour preparation in both directions

Example 1

Generating a contour table with:

- Name "KTAB"
- Max. 30 contour elements (circles, straight lines)
- One variable for the number of relief cut elements that occur
- One variable for fault messages



NC program:

Program code	Comment
N10 DEF REAL KTAB[30,11]	; Contour table with the KTAB name and max. 30 contour elements, parameter value 11 (number of table columns) is a fixed quantity.
N20 DEF INT ANZHINT	; Variable for the number of relief cut elements with the name ANZHINT.
N30 DEF INT ERROR	; Variable for fault feedback signal (0=no fault, 1=fault).
N40 G18	
N50 CONTPRON(KTAB,"G",ANZHINT)	; Activate contour preparation.
N60 G1 X150 Z20	; N60 to N120: Contour description
N70 X110 Z30	
N80 X50 RND=15	
N90 Z70	
N100 X40 Z85	
N110 X30 Z90	
N120 X0	
N130 EXECUTE(ERROR)	; End filling the contour table, change over to normal program operation.
N140 …	; Continue to process the table.

Contour table KTAB:

Index Line	Column									
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
7	7	11	0	0	20	150	0	82.40535663	0	0
0	2	11	20	150	30	110	-1111	104.0362435	0	0
1	3	11	30	110	30	65	0	90	0	0
2	4	13	30	65	45	50	0	180	45	65
3	5	11	45	50	70	50	0	0	0	0
4	6	11	70	50	85	40	0	146.3099325	0	0
5	7	11	85	40	90	30	0	116.5650512	0	0
6	0	11	90	30	90	0	0	90	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0

Explanation of the column contents:

(0) Pointer to next contour element (to the row number of that column)

(1) Pointer to previous contour element

(2) Coding the contour mode for motion

Possible values for X = abc

a = 10^2 G90 = 0 G91 = 1

b = 10^1 G70 = 0 G71 = 1

c = 10^0 G0 = 0 G1 = 1 G2 = 2 G3 = 3

(3), (4) Starting point of contour elements

(3) = abscissa, (4) = ordinate of the current plane

(5), (6) Starting point of the contour elements

(5) = abscissa, (6) = ordinate of the current plane

(7) Max/min indicator: Identifies local maximum and minimum values on the contour

(8) Maximum value between contour element and abscissa (for longitudinal machining) or ordinate (for face cutting). The angle depends on the type of machining programmed.

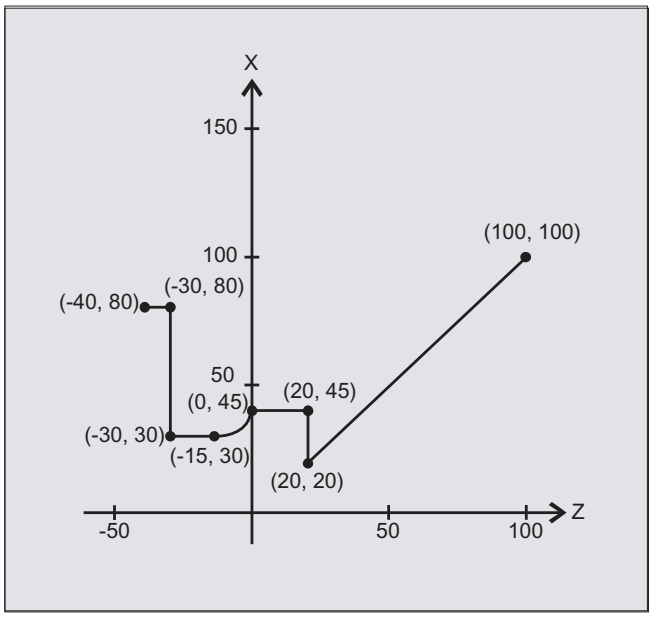
(9), (10) Center point coordinates of contour element, if it is a circle block.

(9) = abscissa, (10) = ordinate

Example 2

Generating a contour table with

- Name KTAB
- Max. 92 contour elements (circles, straight lines)
- Mode: Longitudinal turning, outer machining
- Preparation, forwards and backwards



NC program:

Program code	Comment
N10 DEF REAL KTAB[92,11]	; Contour table with name KTAB and max. 92 contour elements, parameter value 11 is a fixed quantity.
N20 DEF CHAR BT="L"	; Mode for CONTPRON: Longitudinal turning, outer machining
N30 DEF INT HE=0	; Number of relief cut elements=0
N40 DEF INT MODE=1	; Preparation, forwards and backwards
N50 DEF INT ERR=0	; Fault feedback signal
...	
N100 G18 X100 Z100 F1000	
N105 CONTPRON(KTAB,BT,HE,MODE)	; Activate contour preparation.
N110 G1 G90 Z20 X20	
N120 X45	
N130 Z0	
N140 G2 Z-15 X30 K=AC(-15) I=AC(45)	
N150 G1 Z-30	

```
Program code                                    Comment
N160 X80
N170 Z-40
N180 EXECUTE(ERR)                               ; End filling the contour table,
                                                  change over to normal program
                                                  operation.
...
```

Contour table KTAB:

After contour preparation is finished, the contour is available in both directions.

Index	Column										
Line	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
0	6[1)]	7[2)]	11	100	100	20	20	0	45	0	0
1	0[3)]	2	11	20	20	20	45	-3	90	0	0
2	1	3	11	20	45	0	45	0	0	0	0
3	2	4	12	0	45	-15	30	5	90	-15	45
4	3	5	11	-15	30	-30	30	0	0	0	0
5	4	7	11	-30	30	-30	45	-1111	90	0	0
6	7	0[4)]	11	-30	80	-40	80	0	0	0	0
7	5	6	11	-30	45	-30	80	0	90	0	0
8	1[5)]	2[6)]	0	0	0	0	0	0	0	0	0
	...										
83	84	0[7)]	11	20	45	20	80	0	90	0	0
84	90	83	11	20	20	20	45	-1111	90	0	0
85	0[8)]	86	11	-40	80	-30	80	0	0	0	0
86	85	87	11	-30	80	-30	30	88	90	0	0
87	86	88	11	-30	30	-15	30	0	0	0	0
88	87	89	13	-15	30	0	45	-90	90	-15	45
89	88	90	11	0	45	20	45	0	0	0	0
90	89	84	11	20	45	20	20	84	90	0	0
91	83[9)]	85[10)]	11	20	20	100	100	0	45	0	0

Explanation of column contents and comments for lines 0, 1, 6, 8, 83, 85 and 91

The explanations of the column contents given in example 1 apply.

Always in table line 0:

1) Predecessor: Line n contains the contour end (forwards)

2) Successor: Line n is the contour table end (forwards)

Once each within the contour elements forwards:

3) Predecessor: Contour start (forwards)

4) Successor: Contour end (forwards)

Always in line contour table end (forwards) +1:

5) Predecessor: Number of relief cuts (forwards)

6) Successor: Number of relief cuts (backwards)

Once each within the contour elements backwards:

7) Successor: Contour end (backwards)

8) Predecessor: Contour start (backwards)

Always in last line of table:

9) Predecessor: Line n is the contour table start (backwards)

10) Successor: Line n contains the contour start (backwards)

Further Information

Permitted traversing commands, coordinate system

The following G commands can be used for the contour programming:

- G group 1: G0, G1, G2, G3

In addition, the following are possible:

- Rounding and chamfer
- Circle programming using CIP and CT

The spline, polynomial and thread functions result in errors.

Changes to the coordinate system by activating a frame are not permissible between CONTPRON and EXECUTE. The same applies for a change between G70 and G71 or G700 and G710.

Replacing the geometry axes with GEOAX while preparing the contour table produces an alarm.

Relief cut elements

The contour description for the individual relief cut elements can be performed either in a subprogram or in individual blocks.

Stock removal independent of the programmed contour direction

The contour preparation with CONTPRON was expanded so that after it has been called, the contour table is available independent of the programmed direction.

17.3 Generate coded contour table (CONTDCON)

Function

With the contour preparation activated with CONTDCON, the following NC blocks that are called are saved in a coded form in a 6-column contour table to optimize memory use. Each contour element corresponds to one row in the contour table. When familiar with the coding rules specified below, e.g. you can combine DIN code programs for cycles from the table lines. The data of the output point are saved in the table line with the number 0.

Syntax

Activate contour preparation:
```
CONTDCON(<contour table>,<machining direction>)
```

Deactivate contour preparation and return to the normal execution mode:
```
EXECUTE(<ERROR>)
```

See "Deactivate contour preparation (EXECUTE) (Page 640)"

Meaning

CONTDCON	Command to activate the contour preparation to generate a coded contour table		
<contour table>	Names of contour table		
<machining direction>	Parameter for machining direction		
	Type:	INT	
	Value:	0	Contour preparation according to the sequence of contour blocks (default value)
		1	Not permissible

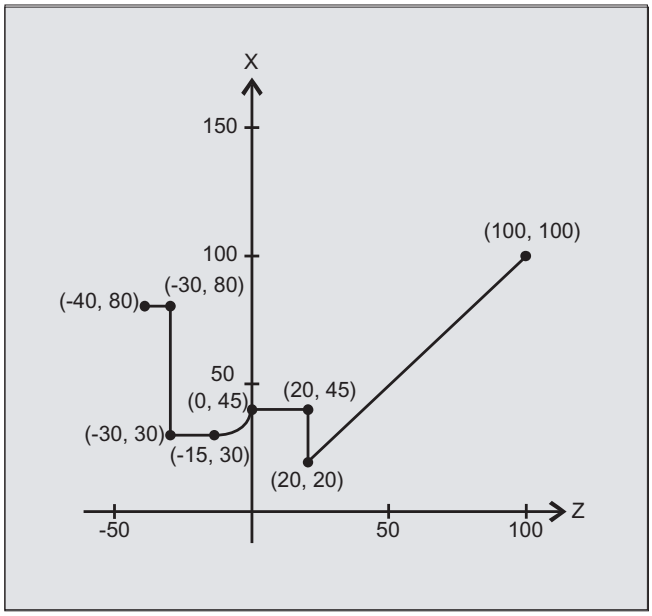
Note

The G codes permitted for CONTDCON in the program section to be included in the table are more comprehensive than for CONTPRON. Further, feed rates and feed rate type are saved for each contour section.

Example

Generating a contour table with:

- Name "KTAB"
- Contour elements (circles, straight lines)
- Mode: Turning
- Machining direction: Forward



NC program:

Program code	Comment
N10 DEF REAL KTAB[9,6]	; Contour table with name KTAB and 9 table cells. These allow 8 contour sets. The parameter value 6 (column number in table) is a fixed size.
N20 DEF INT MODE = 0	; Variable for the machining direction. Standard value 0: Only in the programmed direction of the contour.
N30 DEF INT ERROR = 0	; Variable for the fault feedback signal.
...	
N100 G18 G64 G90 G94 G710	
N101 G1 Z100 X100 F1000	
N105 CONTDCON (KTAB, MODE)	; Call contour preparation (MODE can be omitted).
N110 G1 Z20 X20 F200	; Contour description.
N120 G9 X45 F300	
N130 Z0 F400	
N140 G2 Z-15 X30 K=AC(-15) I=AC(45)F100	
N150 G64 Z-30 F600	
N160 X80 F700	
N170 Z-40 F800	
N180 EXECUTE(ERROR)	; End filling the contour table, change over to normal program operation.
...	

Contour table KTAB:

	Column index					
	0	1	2	3	4	5
Line index	Contour mode	End point abscissa	End point ordinate	Center point abscissa	Center point ordinate	Feedrate
0	30	100	100	0	0	7
1	11031	20	20	0	0	200
2	111031	20	45	0	0	300
3	11031	0	45	0	0	400
4	11032	-15	30	-15	45	100
5	11031	-30	30	0	0	600
6	11031	-30	80	0	0	700
7	11031	-40	80	0	0	800
8	0	0	0	0	0	0

Explanation of the column contents:

Line 0 Coding for the **starting point:**

Column 0: 10^0 (units digit): G0 = 0
10^1 (tens position): G70 = 0, G71 = 1, G700 = 2, G710 = 3
Column 1: Starting point abscissa
Column 2: Starting point ordinate
Column 3-4: 0
Column 5: Line index of last contour piece in the table

Lines 1-n: Entries for **contour pieces**

Column 0: 10^0 (units digit): G0 = 0, G1 = 1, G2 = 2, G3 = 3
10^1 (tens position): G70 = 0, G71 = 1, G700 = 2, G710 = 3
10^2 (hundreds digit): G90 = 0, G91 = 1
10^3 (thousands digit): G93 = 0, G94 = 1, G95 = 2, G96 = 3
10^4 (ten thousands digit): G60 = 0, G44 = 1, G641 = 2, G642 = 3
10^5 (hundred thousands digit): G9 = 1
Column 1: End point abscissa
Column 2: End point ordinate
Column 3: Center point abscissa for circular interpolation
Column 4: Center point ordinate for circular interpolation
Column 5: Feedrate

Further Information

Permitted traversing commands, coordinate system

The following G groups and G commands can be used for the contour programming:

G group 1:	G0, G1, G2, G3
G group 10:	G60, G64, G641, G642
G group 11:	G9
G group 13:	G70, G71, G700, G710
G group 14:	G90, G91
G group 15:	G93, G94, G95, G96, G961

In addition, the following are possible:

- Rounding and chamfer
- Circle programming using CIP and CT

The spline, polynomial and thread functions result in errors.

Changes to the coordinate system by activating a frame are not permissible between CONTDCON and EXECUTE. The same applies for a change between G70 and G71 or G700 and G710.

Replacing the geometry axes with GEOAX while preparing the contour table produces an alarm.

Machining direction

The contour table generated using CONTDCON is used for stock removal in the programmed direction of the contour.

17.4 Determine point of intersection between two contour elements (INTERSEC)

Function

INTERSEC determines the point of intersection of two normalized contour elements from the contour tables generated using CONTPRON.

Syntax

```
<Status>=INTERSEC(<contour table_1>[<contour element_1>],
<contour table_2>[<contour element_2>],<intersection
point>,<machining type>)
```

Meaning

INTERSEC	Key word to determine the point of intersection between two contour elements from the contour tables generated with CONTPRON
<status>	Variable for the point of intersection status Type: BOOL Value: TRUE Point of intersection found FALSE No intersection found
<contour table_1>	Name of the first contour table
<contour element_1>	Number of the contour element of the first contour table
<contour table_2>	Names of the second contour table
<contour element_2>	Number of the contour element of the second contour table
<point of intersection>	Intersection coordinates in the active plane (G17 / G18 / G19) Type: REAL
<machining type>	Parameter for the machining type Type: INT Value: 0 Point of intersection calculation in the active plane with parameter 2 (standard value) 1 Point of intersection calculation independent of the transferred plane

Note

Please note that the variables must be defined before they are used.

The values defined with CONTPRON must be observed when transferring the contours:

Parameter	Meaning
2	Coding of contour mode for the movement
3	Contour start point abscissa
4	Contour start point ordinate
5	Contour end point abscissa
6	Contour end point ordinate
9	Center point coordinates for abscissa (only for circle contour)
10	Center point coordinates for ordinate (only for circle contour)

Example

Calculate the intersection of contour element 3 in table TABNAME1 and contour element 7 in table TABNAME2. The intersection coordinates in the active plane are stored in the variables ISCOORD (1st element = abscissa, 2nd element = ordinate). If no intersection exists, the program jumps to NOCUT (no intersection found).

```
Program code                                                    Comment
DEF REAL TABNAME1[12,11]                                        ; Contour table 1
DEF REAL TABNAME2[10,11]                                        ; Contour table 2
DEF REAL ISCOORD [2]                                            ; Variable for the point of
                                                                  intersection coordinates.
DEF BOOL ISPOINT                                                ; Variable for the intersection
                                                                  status.
DEF INT MODE                                                    ; Variable for machining type.
…
MODE=1                                                          ; Calculation independent of the
                                                                  active plane.
N10 ISPOINT=INTERSEC(TABNAME1[3],TABNAME2[7],ISCOORD,MODE)      ; Call point of intersection of
                                                                  the contour elements.
N20 IF ISPOINT==FALSE GOTOF NOCUT                               ; Jump to NOCUT
…
```

17.5 Execute the contour elements of a table block-by-block (EXECTAB)

Function

Using the command EXECTAB, you can execute the contour elements of a table – that were generated e.g. using the command CONTPRON – block-by-block.

Syntax

```
EXECTAB(<contour table>[<contour element>])
```

Meaning

EXECTAB	Command to execute a contour element
<contour table>	Names of contour table
<contour element>	Number of the contour element

Example

Contour elements 0 to 2 in table KTAB should be executed block-by-block.

```
Program code                    Comment
N10 EXECTAB(KTAB[0])            ; Traverse element 0 of table KTAB.
N20 EXECTAB(KTAB[1])            ; Traverse element 1 of table KTAB.
N30 EXECTAB(KTAB[2])            ; Traverse element 2 of table KTAB.
```

17.6 Calculate circle data (CALCDAT)

Function

Using the CALCDAT command, you can calculate the radius and the circle center point coordinates from the three or four points known along the circle The specified points must be different. Where four points do not lie directly on the circle an average value is taken for the circle center point and the radius.

Syntax

```
<Status>=CALCDAT(<circle points>[<number>,<type>],<number>,<result>)
```

Meaning

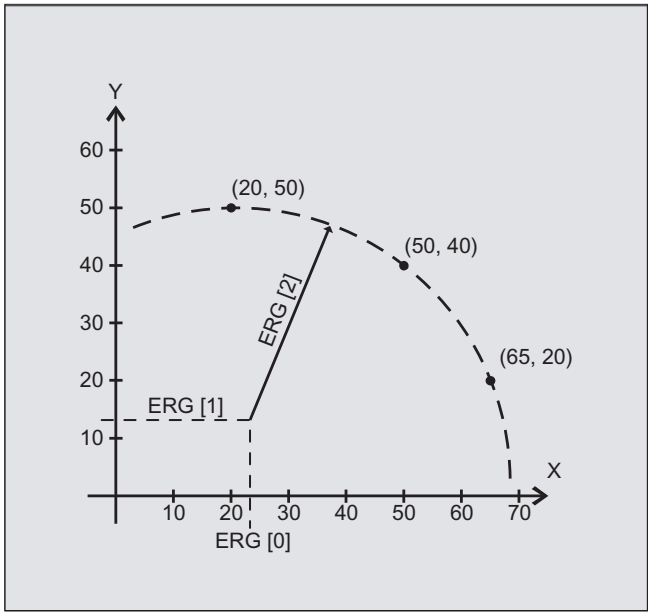
CALCDAT	Command to calculate the radius and center point coordinates of a circle from 3 or 4 points
<status>	Variable for the circle calculation status Type: BOOL Value: TRUE The specified points lie on a circle. FALSE The specified points **do not** lie on a circle.
<circle points>[]	Variable to specify the circle points using parameters <number> Number of circle points (3 or 4) <type> Type of coordinate data, e.g. 2 for 2-point coordinates
<number>	Parameter for the number of the points used for the calculation (3 or 4)
<result>[3]	Variable for result: Circle center point coordinates and radius 0 Circle center point coordinate: Abscissa value 1 Circle center point coordinate: Ordinate value 2 Radius

Note

Please note that the variables must be defined before they are used.

Example

Using three points it should be determined as to whether they are located on a circle segment.



Program code	Comment
N10 DEF REAL PT[3,2]=(20,50,50,40,65,20)	; Variable to specify the points along a circle
N20 DEF REAL RES[3]	; Variable for result
N30 DEF BOOL STATUS	; Variable for status
N40 STATUS=CALCDAT(PKT,3,ERG)	; Call the determined circle data.
N50 IF STATUS == FALSE GOTOF ERROR	; Jump to error

17.7 Deactivate contour preparation (EXECUTE)

Function

The command EXECUTE is used to deactivate the contour preparation and at the same time the system returns to the normal execution mode.

Syntax

```
EXECUTE(<ERROR>)
```

Meaning

EXECUTE	Command to terminate contour preparation
<FAULT>	Variable for the fault feedback signal Type: INT The value of the variable indicates whether the contour was able to be prepared error-free: 0 Error 1 No error

Example

Program code

```
...
N30 CONTPRON(...)
N40 G1 X... Z...
...
N100 EXECUTE(...)
...
```

Programming cycles externally 18

18.1 Technology cycles

18.1.1 Introduction

Contents

This chapter describes the technology cycles from version 2.6 onwards for creating external NC programs.

Structure

The documentation is structured as follows:

- **Programming**

  Cycle name and call sequence of the transfer parameters

- **Parameters**

  Tables to explain the individual parameters

Parameter description

The table contains the names of the parameters used internally and an explanation of what they mean and the possible value range. The relationships between the parameters are also explained. The column for reference to the parameter in the mask is to be used to locate programmed values again when externally generated cycle calls to the controller are recompiled.

"For interface only" parameters

Certain parameters are marked "for interface only" in the table. These are not relevant to operation of the cycle. They are only needed in order to be able to recompile cycle calls completely. If they are not programmed the cycle can still be recompiled; the fields are then identified by color and must be completed in the mask.

"Reserved" parameters

Parameters that are described as "reserved" must be programmed with the value 0 or a comma so that the assignment of the following call parameters matches up with the internal cycle parameters. Exception: string parameters with the value "" or a comma.

Compatibility

The technology cycles from version 2.6 onwards are a further development of the cycle packages for SINUMERIK 840D sl up to GIV 1.5 (cycles up to version 7.5). NC programs with cycle calls for these earlier software versions will still run.

Most cycles have been extended by new transfer parameters or the range of existing parameters has been extended in order that new functions can be programmed (e.g. Parameter _VARI for the type of machining, which is used often).

The term "Compatibility" in this documentation indicates input values that have not been programmed before. If values are supplied accordingly, the cycle runs with the same functions as up to version 7.5.

Repeating cycles on a position pattern

Drilling and milling cycles can be repeated on the position pattern (modal calls). In such cases `MCALL` should be written in the same line before the cycle, e.g. `MCALL CYCLE83(...)`.

Note

If certain transfer parameters (e.g. `_VARI`, `_GMODE`, `_DMODE`, `_AMODE`) have been indirectly programmed as parameters, the input mask is opened on recompiling but it cannot be stored as there is no unique assignment to defined selection fields.

18.1.2 Drilling, centering - CYCLE81

Programming

```
CYCLE81(REAL RTP, REAL RFP, REAL SDIS, REAL DP, REAL DPR, REAL _DTB,
INT _GMODE, INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	RTP	Retraction plane (abs)
2	Z0	RFP	Reference point (abs)
3	SC	_SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1/⌀	_DP	Drilling depth (abs)/ centering diameter (abs), see _GMODE
5	Z1	-DPR	Drilling depth (inc)
6	DT	_DTB	Dwell time at final drilling depth, see _AMODE

No.	Param mask	Param internal	Explanation
7		_GMODE	Geometrical mode (evaluation of programmed geometrical data)
			UNITS: Reserved
			TENS: Centering with respect to depth/diameter
			0 = Compatibility, depth
			1 = Diameter
8		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
9		_AMODE	Alternative mode
			UNITS: Drilling depth Z1 (abs/inc)
			0 = Compatibility, from DP/DPR programming
			1 = Incremental
			2 = Absolute
			TENS: Dwell time at final drilling depth DT in seconds/revolutions
			0 = Compatibility, from DTB sign (> 0 seconds or < 0 revolutions)
			1 = In seconds
			2 = In revolutions

18.1.3 Drilling, counterboring - CYCLE82

Programming

```
CYCLE82(REAL RTP, REAL RFP, REAL SDIS, REAL DP, REAL DPR, REAL DTB,
INT _GMODE, INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param intern	Explanation
1	RP	RTP	Retraction plane (abs)
2	Z0	RFP	Reference point (abs)
3	SC	SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	DP	Drilling depth (abs), see _AMODE
5	Z1	DPR	Drilling depth (inc), see _AMODE
6	DT	DTB	Dwell time at final drilling depth, see _AMODE

No.	Param mask	Param intern	Explanation
7		_GMODE	Geometrical mode (evaluation of programmed geometrical data)
			UNITS: Reserved
			TENS: Drilling depth with respect to tip/shank
			0 = Compatibility, tip
			1 = Shank
8		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
9		_AMODE	Alternative mode
			UNITS: Drilling depth Z1 (abs/inc)
			0 = Compatibility, from DP/DPR programming
			1 = Incremental
			2 = Absolute
			TENS: Dwell time DT at final drilling depth in seconds/revolutions
			0 = Compatibility, from DT sign (> 0 seconds / < 0 revolutions)
			1 = In seconds
			2 = In revolutions

18.1.4 Reaming - CYCLE85

Programming

```
CYCLE85(REAL RTP, REAL RFP, REAL SDIS, REAL DP, REAL DPR, REAL DTB,
REAL FFR, REAL RFF, INT _GMODE, INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	RTP	Retraction plane (abs)
2	Z0	RFP	Reference point (abs)
3	SC	SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	DP	Drilling depth (abs), see _AMODE
5	Z1	DPR	Drilling depth (inc), see _AMODE
6	DT	DTB	Dwell time at final drilling depth, see _AMODE
7	F	FFR	Feedrate

No.	Param mask	Param internal	Explanation
8	FR	RFF	Feedrate during retraction
9		_GMODE	Reserved
10		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
11		_AMODE	Alternative mode (drilling)
			UNITS: Drilling depth Z1 (abs/inc)
			0 = Compatibility, from DP/DPR programming
			1 = Incremental
			2 = Absolute
			TENS: Dwell time DT at final drilling depth in seconds/revolutions
			0 = Compatibility, from DT sign (> 0 seconds or < 0 revolutions)
			1 = In seconds
			2 = In revolutions

18.1.5 Deep-hole drilling - CYCLE83

Programming

```
CYCLE83(REAL RTP, REAL RFP, REAL SDIS, REAL DP, REAL DPR, REAL FDEP,
REAL FDPR, REAL _DAM, REAL DTB, REAL DTS, REAL FRF, INT VARI, INT
_AXN, REAL _MDEP, REAL _VRT, REAL _DTD, REAL _DIS1, INT _GMODE, INT
_DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	RTP	Retraction plane (abs)
2	Z0	RFP	Reference point (abs)
3	SC	SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	DP	Final drilling depth (abs), see _AMODE
5	Z1	DPR	Final drilling depth (inc), see _AMODE
6	D	FDEP	1st drilling depth (abs), see _AMODE
7	D	FDPR	1st drilling depth (inc), see _AMODE

No.	Param mask	Param internal	Explanation
8	DF	_DAM	Amount/percentage for each additional infeed (degression amount/percentage), see _AMODE
9	DTB	DTB	Dwell time at drilling depth, see _AMODE
10	DTS	DTS	Dwell time at start point (for chip removal only), see _AMODE
11	FD1	FRF	Percentage for the feedrate for the first infeed, see _AMODE
12		VARI	Machining type
			UNITS: Chip breaking/removal
			0 = Chip breaking
			1 = Chip removal
13		_AXN	Tool axis:
			0 = 3rd geometry axis
			1 = 1st geometry axis
			2 = 2nd geometry axis
			> 2 = 3rd geometry axis
14	V1	_MDEP	Minimum infeed (only for degression percentage)
15	V2	_VRT	Retraction distance after each machining step (for chip breaking only)
			> 0 = Variable retraction distance
			0 = Standard value 1 mm
16	DT	_DTD	Dwell time at final drilling depth, see _AMODE
17	V3	_DIS1	Limit distance (for chip removal only), see _AMODE
18		_GMODE	Geometrical mode (evaluation of programmed geometrical data)
			UNITS: Reserved
			TENS: Drilling depth with respect to tip/shank
			0 = Tip
			1 = Shank
19		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)

No.	Param mask	Param internal	Explanation
20		_AMODE	Alternative mode
			UNITS: Drilling depth = Final drilling depth Z1 (abs/inc)
			0 = Compatibility, from DP/DPR programming
			1 = Incremental
			2 = Absolute
			TENS: Dwell time at drilling depth DTB in seconds/revolutions
			0 = Compatibility from DTB sign (> 0 seconds or < 0 revolutions)
			1 = In seconds
			2 = In revolutions
			HUNDREDS: Dwell time at start point of DTS in seconds/revolutions
			0 = Compatibility from DTS sign (> 0 seconds or < 0 revolutions)
			1 = In seconds
			2 = In revolutions
			THOUSANDS: Dwell time at final drilling depth DT in seconds/revolutions
			0 = Compatibility from DTD sign (> 0 seconds or < 0 revolutions)
			1 = In seconds
			2 = In revolutions
			TEN THOUSANDS: 1. Drilling depth D (abs/inc)
			0 = Compatibility, from FDEP/FDPR programming
			1 = Incremental
			2 = Absolute
			HUNDRED THOUSANDS: Amount/percentage DAM for each additional infeed (degression)
			0 = Compatibility, from DAM sign (> 0 seconds or < 0 factor 0.001 to 1.0)
			1 = Amount
			2 = Percentage (0.001 up to 100%)
			ONE MILLION: Limit distance V3 automatic/manual
			0 = Compatibility from _DIS1 sign (= 0 automatic or > 0 manual)
			1 = Automatic (calculated in the cycle)
			2 = Manual (programmed value)
			TEN MILLION: Feed rate factor for first infeed FRF as factor/percentage
			0 = Compatibility, as a factor (0.001 to 1.0, FRF = 0 means 100%)
			1 = Percentage (0.001 up to 999,999%)

18.1.6 Boring - CYCLE86

Programming

```
CYCLE86(REAL RTP, REAL RFP, REAL SDIS, REAL DP, REAL DPR, REAL DTB,
INT SDIR, REAL RPA, REAL RPO, REAL RPAP, REAL POSS, INT _GMODE, INT
_DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	RTP	Retraction plane (abs)
2	Z0	RFP	Reference point (abs)
3	SC	SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	DP	Drilling depth (abs), see _AMODE
5	Z1	DPR	Drilling depth (inc), see _AMODE
6	DT	DTB	Dwell time at final drilling depth, see _AMODE
7	DIR	SDIR	Direction of spindle rotation 3 = M3 4 = M4
8	DX	RPA	Lift-off distance in X direction
9	DY	RPO	Lift-off distance in the Y direction
10	DZ	RPAP	Lift-off distance in the Z direction
11	SPOS	POSS	Spindle position for lift-off (for oriented spindle stop, in degrees)
12		_GMODE	Geometrical mode
			UNITS: Lift mode
			0 = Lift off, compatibility 1 = Do not lift off
13		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the plane effective before cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
14		_AMODE	Alternative mode
			UNITS: Drilling depth Z1 (abs/inc)
			0 = Compatibility, from DP/DPR programming 1 = Incremental 2 = Absolute
			TENS: Dwell time at final drilling depth DT in seconds/revolutions

No.	Param mask	Param internal	Explanation
			0 = Compatibility, from DT sign (> 0 seconds or < 0 revolutions)
			1 = In seconds
			2 = In revolutions

18.1.7 Tapping without compensating chuck - CYCLE84

Programming

```
CYCLE84(REAL RTP, REAL RFP, REAL SDIS, REAL DP, REAL DPR, REAL DTB,
INT SDAC, REAL MPIT, REAL PIT, REAL POSS, REAL SST, REAL SST1, INT
_AXN, INT _PITA, INT _TECHNO, INT _VARI, REAL _DAM, REAL _VRT,
STRING[15] _PITM, STRING[5] _PTAB, STRING[20] _PTABA, INT _GMODE,
INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	RTP	Retraction plane (abs)
2	Z0	RFP	Reference point (abs)
3	SC	SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	DP	Drilling depth = final drilling depth (abs), see _AMODE
5	Z1	DPR	Drilling depth = final drilling depth (inc), see _AMODE
6	DT	DTB	Dwell time at drilling depth in seconds
7	SDE	SDAC	Direction of rotation after end of cycle
8		MPIT	Thread size for "ISO metric" only (pitch is calculated internally during run time)
9	P	PIT	Pitch as a value, for unit see _PITA
10	αS[1)]	POSS	Spindle position for oriented spindle stop
11	S	SST	Spindle speed for tapping
12	SR	SST1	Spindle speed for retraction
13		_AXN	Drilling axis:
			0 = 3rd geometry axis
			1 = 1st geometry axis
			2 = 2nd geometry axis
			≥ 3 = 3rd geometry axis

No.	Param mask	Param internal	Explanation	
14		_PITA	Unit for thread pitch	(evaluation of PIT and MPIT)
			0 = Pitch in mm	- evaluation of MPIT/PIT
			1 = Pitch in mm	- evaluation of PIT
			2 = Pitch in TPI	- evaluation of PIT (threads per inch)
			3 = Pitch in inches	- evaluation of PIT
			4 = MODULE	- evaluation of PIT
15		_TECHNO	Technology[1)]	
			UNITS: Exact stop response	
			0 = Exact stop response active as before cycle call	
			1 = Exact stop G601	
			2 = Exact stop G602	
			3 = Exact stop G603	
			TENS: Feedforward control	
			0 = With/without feedforward control active as before cycle call	
			1 = With feedforward control FFWON	
			2 = Without feedforward control FFWOF	
			HUNDRED: Acceleration	
			0 = SOFT/BRISK/DRIVE active as before cycle call	
			1 = With jerk limiting SOFT	
			2 = Without jerk limiting BRISK	
			3 = Reduced acceleration DRIVE	
			THOUSANDS: MCALL spindle mode	
			0 = On MCALL reactivate spindle operation	
			1 = On MCALL remain in position control	
16		_VARI	Machining type:	
			UNITS:	
			0 = 1 cut	
			1 = Chip breaking (deep hole tapping)	
			2 = Chip removal (deep hole tapping)	
			THOUSANDS: ISO/SIEMENS mode not relevant for input mask	
			1 = Call from ISO compatibility	
			0 = Call from SIEMENS context	
17	D	_DAM	Maximum depth infeed (for chip removal/breaking only)	
18	V2	_VRT	Retraction distance after each machining step (for chip breaking only), see _AMODE	
19		_PITM	String as marker for pitch input[2)]	
20		_PTAB	String for thread table ("", "ISO", "BSW", "BSP", "UNC")[2)]	
21		_PTABA	String for selection from thread table (e.g. "M 10", "M 12", ...)[2)]	
22		_GMODE	Geometrical mode (evaluation of programmed geometrical data)	
			UNITS: Reserved	
			TENS: Reserved	

No.	Param mask	Param internal	Explanation
23		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
			TENS: Reserved
			HUNDREDS: Reserved
			THOUSANDS: Compatibility mode (or recompilation input mask only), if MD 52216 bit0 = 1[1)]
			0 = Technological parameters are displayed (compatibility): TECHNO parameters effective
			1 = Technology parameters are not displayed: technology active "as before cycle call"
24		_AMODE	Alternative mode
			UNITS: Drilling depth = Final drilling depth Z1 (abs/inc)
			0 = Compatibility, from DP/DPR programming
			1 = Incremental
			2 = Absolute
			TENS: Reserved
			HUNDREDS: Reserved
			THOUSANDS: Thread direction of rotation right/left
			0 = Compatibility, from PIT/MPTI sign
			1 = Right
			2 = Left
			TEN THOUSANDS: Reserved
			HUNDRED THOUSANDS: Reserved
			ONE MILLION: Retraction distance after each machining step V2 manual/automatic
			0 = Compatibility, from _VRT programming (> 0 variable value or ≤ 0 standard value 1 mm / 0.0394 inch)
			1 = Automatic (standard value 1 mm / 0.0394 inch)
			2 = Manual (programmed as under V2)

[1)] Technology fields may be hidden, depending on the setting date SD52216 $MCS_FUNCTION_MASK_DRILL

[2)] Parameters 19, 20 and 21 are only used for thread selection in the input mask thread tables. The thread tables cannot be accessed via cycle definition in the cycle run time.

18.1.8 Tapping with compensating chuck - CYCLE840

Programming

```
CYCLE840(REAL RTP, REAL RFP, REAL SDIS, REAL DP, REAL DPR, REAL DTB,
INT SDR, INT SDAC, INT ENC, REAL MPIT, REAL PIT, INT _AXN, INT
_PITA, INT _TECHNO, STRING[15] _PITM, STRING[5] _PTAB, STRING[20]
_PTABA, INT _GMODE, INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation	
1	RP	RTP	Retraction plane (abs)	
2	Z0	RFP	Reference point (abs)	
3	SC	SDIS	Safety clearance (to be added to reference point, enter without sign)	
4	Z1	DP	Drilling depth (abs), see _AMODE	
5	Z1	DPR	Drilling depth (inc), see _AMODE	
6	DT	DTB	Dwell time in seconds at drilling depth/safety clearance after retraction, see ENC	
7		SDR	Direction of rotation for retraction	
8	SDE	SDAC	Direction of rotation after end of cycle	
9		ENC	Tapping with spindle mounted encoder (G33)/tapping without spindle mounted encoder (G63)	
			0 = With spindle mounted encoder 20 = With spindle mounted encoder	- Pitch from MPIT/PIT - without DT - Pitch from MPIT/PIT - with DT after retraction to safety clearance - Pitch from MPIT/PIT - with DT at drilling depth
			11 = Without spindle mounted encoder 1 = Without spindle mounted encoder	- Pitch from programmed feedrate - with DT at drilling depth (feedrate = speed · pitch)
10		MPIT	Thread size for "ISO metric" only (pitch is calculated internally during run time) Range of values: 3 to 48 (for M3 to M48), alternative to PIT	
11		PIT	Pitch as a value, for unit see _PITA) Range of values: > 0, alternative to MPIT	
12		_AXN	Drilling axis: 0 = 3rd geometry axis 1 = 1st geometry axis 2 = 2nd geometry axis ≥ 3 = 3rd geometry axis	

No.	Param mask	Param internal	Explanation	
13		_PITA	Pitch unit (evaluation of PIT and MPIT)	
			0 = Pitch in mm	- evaluation of MPIT/PIT
			1 = Pitch in mm	- evaluation of PIT
			2 = Pitch in TPI	- evaluation of PIT (threads per inch)
			3 = Pitch in inches	- evaluation of PIT
			4 = MODULE	- evaluation of PIT
14		_TECHNO	Technology[1]	
			UNITS: Exact stop response	
			0 = Exact stop active as before cycle call	
			1 = Exact stop G601	
			2 = Exact stop G602	
			3 = Exact stop G603	
			TENS: Feedforward control	
			0 = With/without feedforward control active as before cycle call	
			1 = With feedforward control FFWON	
			2 = Without feedforward control FFWOF	
15		_PITM	String as marker for pitch input[2]	
16		_PTAB	String for thread table ("", "ISO", "BSW", "BSP", "UNC")[2]	
17		_PTABA	String for selection from thread table (e.g. "M 10", "M 12", ...)[2]	
18		_GMODE	Reserved	
19		_DMODE	Display mode	
			UNITS: Machining plane G17/G18/G19	
			0 = Compatibility, the plane effective before cycle call remains active	
			1 = G17 (only active in the cycle)	
			2 = G18 (only active in the cycle)	
			3 = G19 (only active in the cycle)	
			TENS: Reserved	
			HUNDREDS: Reserved	
			THOUSANDS: Compatibility mode (or recompilation input mask only), if MD 52216 bit0 = 1[1]	
			0 = Technological parameters are displayed (compatibility): TECHNO parameters effective	
			1 = Technology parameters are not displayed: technology active "as before cycle call"	
20		_AMODE	Alternative mode	
			UNITS: Drilling depth Z1 (abs/inc)	
			0 = Compatibility, from DP/DPR programming	
			1 = Incremental	
			2 = Absolute	

[1] Technology fields may be hidden, depending on the setting date SD52216 MCS_FUNCTION_MASK_DRILL

[2] Parameters 15, 16 and 17 are only used for thread selection in the input mask thread tables. The thread tables cannot be accessed via cycle definition in cycle run time.

18.1.9 Thread milling - CYCLE78

Programming

```
CYCLE78(REAL _RTP, REAL _RFP, REAL _SDIS, REAL _DP, REAL _ADPR, REAL
_FDPR, REAL _LDPR, REAL _DIAM, REAL _PIT, INT _PITA, REAL _DAM, REAL
_MDEP, INT _VARI, INT _CDIR, REAL _GE, REAL _FFD, REAL _FRDP, REAL
_FFR, REAL _FFP2, INT _FFA, STRING[15] _PITM, STRING[20] _PTAB,
STRING[20] _PTABA, INT _GMODE, INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	_RTP	Retraction plane (abs)
2	Z0	_RFP	Reference point of tool axis (abs)
3	SC	_SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	_DP	Final drilling depth (abs/inc), see _AMODE
5		_ADPR	Predrilling depth with reduced drilling feedrate (inc) effective with VARI TEN THOUSAND
6	D	_FDPR	Maximum depth infeed (inc) D ≥ Z1 ⇒ One infeed to the final drilling depth D < Z1 ⇒ Deep drilling cycle with multiple infeeds and chip removal
7	ZR	_LDPR	Remaining drilling depth when through-drilling (inc) with FR feed
8	⌀	_DIAM	Nominal diameter of the thread
9	P	_PIT	Pitch as a numerical value
10		_PITA	Evaluation of thread pitch P 1 = Pitch in mm/rev 2 = Pitch in threads/inch 3 = Pitch in inches/rev 4 = Pitch as MODULE
11	DF	_DAM	Amount/percentage for each additional infeed (degression), see _AMODE
12	V1	_MDEP	Minimum infeed (inc), only active for degression
13		_VARI	Machining type
			UNITS: Reserved
			TENS:
			0 = No chip removal before thread milling (only active at final drilling depth)
			1 = Chip removal before thread milling (only active at final drilling depth)
			HUNDREDS:
			0 = Right-hand thread
			1 = Left-hand thread
			THOUSANDS:
			0 = No remaining drilling depth with drilling feedrate FR
			1 = Remaining drilling depth at drilling feedrate FR

No.	Param mask	Param internal	Explanation
			TEN THOUSANDS:
			0 = No predrilling with reduced feedrate
			1 = Predrilling with reduced feedrate
			Predrilling feed rate = 0.3 F1, if F1< 0.15 mm/rev
			Predrilling feedrate = 0.1 mm/rev, if F1 ≥ 0.15 mm/rev
14		_CDIR	Milling direction
			0 = Down-cut
			1 = Up-cut
			4 = Conventional + climbing (combined roughing + finishing)
15	Z2	_GE	Retraction distance before thread milling (inc)
16	F1	_FFD	Drilling feedrate (mm/min or in/min or mm/rev)
17	FR	_FRDP	Drilling feedrate for remaining drilling depth (mm/min or mm/rev)
18	F2	-FFR	Feedrate for thread milling (mm/min or mm/tooth)
19	FS	_FFP2	Finishing feedrate for CDIR=4 (mm/min or mm/tooth)
20		_FFA	Evaluation of feed rates
			UNITS: Drilling feed F1
			TENS: Drilling feed rate for remaining drilling depth FR
			HUNDREDS: Feedrate for thread milling F2
			THOUSANDS: Finishing feed rate FS
21		_PITM	String as marker for pitch input (for the interface only)[1)]
22		_PTAB	String for thread table ("", "ISO", "BSW", "BSP", "UNC") (for the interface only)[1)]
23		_PTABA	String for selection from thread table (e.g. "M 10", "M 12", ...) (for the interface only)[1)]
24		_GMODE	Geometrical mode, reserved
25		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
26		_AMODE	Alternative mode
			UNITS: Drilling depth = Final drilling depth Z1 abs/inc
			0 = Absolute
			1 = Incremental
			TENS: Amount/percentage DF for each additional infeed (degression)
			0 = Amount
			1 = Percentage (0.001 up to 100%)

Note

[1)] Parameters 21, 22 and 23 are only used for thread selection in the input mask thread tables. The thread tables cannot be accessed via cycle definition in the cycle run time.

18.1.10 Freely programmable positions - CYCLE802

Programming

```
CYCLE802(INT _XA, INT _YA, REAL _X0, REAL _Y0, REAL _X1, REAL _Y1,
REAL _X2, REAL _Y2, REAL _X3, REAL _Y3, REAL _X4, REAL _Y4, REAL
_X5, REAL _Y5, REAL _X6, REAL _Y6, REAL _X7, REAL _Y7, REAL _X8,
REAL _Y8, INT _VARI, INT _UMODE, INT _DMODE)
```

Parameters

No.	Param mask	Param intern	Explanation
1		_XA	Alternatives for all X positions (9-digit decimal value) Number of digits: 876543210 (digit position corresponds to drilling position Xn) Position value: 1 = Absolute (1st programmed position is always absolute) 2 = Incremental
2		_YA	Alternatives for all Y positions (9-digit decimal value) Number of digits: 876543210 (digit position corresponds to drilling position Yn) Position value: 1 = Enter position (abs) 2 = Enter position (inc)
3	X0	_X0	1st position X
4	Y0	_Y0	1st position Y
5	X1	_X1	2nd position X
6	Y1	_Y1	2nd position Y
7	X2	_X2	3rd position X
8	Y2	_Y2	3rd position Y
9	X3	_X3	4th position X
10	Y3	_Y3	4th position Y
11	X4	_X4	5th position X
12	Y4	_Y4	5th position Y
13	X5	_X5	6th position X
14	Y5	_Y5	6th position Y

No.	Param mask	Param intern	Explanation
15	X6	_X6	7th position X
16	Y6	_Y6	7th position Y
17	X7	_X7	8th position X
18	Y7	_Y7	8th position Y
19	X8	_X8	9th position X
20	Y8	_Y8	9th position Y
21		_VARI	Reserved
22		_UMODE	Reserved
23		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)

Note

Positions that are not required for parameters X1/Y1 to X8/Y8 can be ignored.

The alternative values for _XA and _YA, however, must be provided in full for all 9 positions.

18.1.11 Row of holes - HOLES1

Programming

```
HOLES1(REAL SPCA, REAL SPCO, REAL STA1, REAL FDIS, REAL DBH, INT
NUM, INT _VARI, INT _UMODE, STRING[200] _HIDE, INT _NSP, INT _DMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	X0	SPCA	Reference point for row of holes along the 1st axis (abs)
2	Y0	SPCO	Reference point for row of holes along the 2nd axis (abs)
3	α0	STA1	Basic angle of rotation (angle to 1st axis)
4	L0	FDIS	Distance from 1st hole to reference point
5	L	DBH	Spacing between the holes
6	N	NUM	Number of holes

No.	Param mask	Param internal	Explanation
7		_VARI	Reserved
8		_UMODE	Reserved
9		_HIDE	Hidden positions • Max. 198 characters • Specification of consecutive position numbers, e.g. "1,3" (positions 1 and 3 are not executed)
10		_NSP	Reserved
11		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)

18.1.12 Grid or frame - CYCLE801

Programming

```
CYCLE801(REAL _SPCA, REAL _SPCO, REAL _STA, REAL _DIS1, REAL _DIS2,
INT _NUM1, INT _NUM2, INT _VARI, INT _UMODE, REAL _ANG1, REAL _ANG2,
STRING[200] _HIDE, INT _NSP, INT _DMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	X0	_SPCA	Reference point for position pattern (grid/frame) along the 1st axis (abs)
2	Y0	_SPCO	Reference point for position pattern (grid/frame) along the 2nd axis (abs)
3	α0	_STA	Basic angle of rotation (angle to 1st axis) < 0 = Clockwise rotation > 0 = Counter-clockwise rotation
4	L1	_DIS1	Distance for columns (distance from the 1st axis, enter without sign)
5	L2	_DIS2	Distance for rows (distance from the 2nd axis, enter without sign)
6	N1	_NUM1	Number of columns
7	N2	_NUM2	Number of rows

No.	Param mask	Param internal	Explanation
8		_VARI	Machining type
			UNITS: Position pattern
			0 = Grid
			1 = Frame
			TENS: Reserved
			HUNDREDS: Reserved
9		_UMODE	Reserved
10	αX	_ANG1	Shear angle with 1st axis (lines arranged obliquely to the 1st axis) < 0 = Clockwise measurement (0 to -90 degrees) > 0 = Counter-clockwise measurement (0 to 90 degrees)
11	αY	_ANG2	Shear angle with 2nd axis (lines arranged obliquely to the 2nd axis) < 0 = Clockwise measurement (0 to -90 degrees) > 0 = Counter-clockwise measurement (0 to 90 degrees)
12		_HIDE	Hidden positions • Max. 198 characters • Specification of consecutive position numbers, e.g. "1,3" (positions 1 and 3 are not executed)
13		_NSP	Reserved
14		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the levels effective before cycle call remain active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)

18.1.13 Circle of holes - HOLES2

Programming

```
HOLES2(REAL CPA, REAL CPO, REAL RAD, REAL STA1, REAL INDA, INT NUM,
INT _VARI, INT _UMODE, STRING[200] _HIDE, INT _NSP, INT _DMODE)
```

Parameters

No.	Param mask	Param intern	Explanation
1	X0	CPA	Center point for circle of holes along the 1st axis (abs)
2	Y0	CPO	Center point for circle of holes along the 2nd axis (abs)
3	R	RAD	Radius of the circle of holes

No.	Param mask	Param intern	Explanation
4	α0	STA1	Starting angle
5	α1	INDA	Advance angle (for pitch circle only) < 0 = Clockwise > 0 = Counter-clockwise
6	N	NUM	Number of positions
7		_VARI	Machining type
			UNITS: Reserved
			TENS: Positioning type
			0 = Approach position - linear 1 = Approach position - circular path
			HUNDREDS: : Reserved
			THOUSANDS: Circular pattern
			0 = Compatibility mode, if INDA = 0 then full circle, INDA <> 0 then pitch circle) 1 = Full circle 2 = Pitch circle
8		_UMODE	Reserved
9		_HIDE	Hidden positions • Max. 198 characters • Specification of consecutive position numbers, e.g. "1,3" (positions 1 and 3 are not executed)
10		_NSP	Reserved
11		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the plane effective before cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)

18.1.14 Face milling - CYCLE61

Programming

```
CYCLE61(REAL _RTP, REAL _RFP, REAL _SDIS, REAL _DP, REAL _PA, REAL
_PO, REAL _LENG, REAL _WID, REAL _MID, REAL _MIDA, REAL _FALD, REAL
_FFP1, INT _VARI, INT _LIM, INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	_RTP	Retraction plane (abs)
2	Z0	_RFP	Reference point of tool axis, height of blank (abs)
3	SC	_SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	_DP	Height of finished part (abs/inc), see _AMODE
5	X0	_PA	Corner point 1 in 1st axis (abs)
6	Y0	_PO	Corner point 1 in 2nd axis (abs)
7	X1	_LENG	Corner point 2 in 1st axis (abs/inc,) see _AMODE
8	Y1	_WID	Corner point 2 in 2nd axis (abs/inc,) see _AMODE
9	DZ	_MID	Maximum depth infeed
10	DXY	_MIDA	Maximum plane infeed (for unit, see _AMODE)
11	UZ	_FALD	Finishing allowance, depth
12	F	_FFP1	Machining feedrate
13		_VARI	Machining type
			UNITS: Machining
			1 = Roughing
			2 = Finishing
			TENS: Machining direction
			1 = Parallel to the 1st axis, in one direction
			2 = Parallel to the 2nd axis, in one direction
			3 = Parallel to the 1st axis, varying direction
			4 = Parallel to the 2nd axis, varying direction
14		_LIM	Limits
			UNITS: Limit 1st axis negative
			0 = No
			1 = Yes
			TENS: Limit 1st axis positive
			0 = No
			1 = Yes
			HUNDREDS: Limit 2nd axis negative
			0 = No
			1 = Yes

No.	Param mask	Param internal	Explanation
			THOUSANDS: Limit 2nd axis positive
			0 = No
			1 = Yes
15		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
16		_AMODE	Alternative mode
			UNITS: Final depth (_DP)
			0 = Absolute
			1 = Incremental
			TENS: Unit for plane infeed (_MIDA)
			0 = mm
			1 = % of tool diameter
			HUNDREDS: Reserved
			THOUSANDS: Length of surface
			0 = Incremental
			1 = Absolute
			TEN THOUSANDS: Width of surface
			0 = Incremental
			1 = Absolute

18.1.15 Milling a rectangular pocket - POCKET3

Programming

```
POCKET3(REAL _RTP, REAL _RFP, REAL _SDIS, REAL _DP, REAL _LENG, REAL
_WID, REAL _CRAD, REAL _PA, REAL _PO, REAL _STA, REAL _MID, REAL
_FAL, REAL _FALD, REAL _FFP1, REAL _FFD, INT _CDIR, INT _VARI, REAL
_MIDA, REAL _AP1, REAL _AP2, REAL _AD, REAL _RAD1, REAL _DP1, INT
_UMODE, REAL _FS, REAL _ZFS, INT _GMODE, INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	_RTP	Retraction plane (abs)
2	Z0	_RFP	Reference point of tool axis (abs)

No.	Param mask	Param internal	Explanation
3	SC	_SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	_DP	Pocket depth (abs/inc), see _AMODE)
5	L	_LENG	Pocket length (inc, to be entered with sign)
6	W	_WID	Pocket width (inc, to be entered with sign)
7	RP	_CRAD	Corner radius of pocket
8	X0	_PA	Reference point, 1st axis (abs)
9	YO	_PO	Reference point, 2nd axis (abs)
10	α0	_STA	Angle of rotation, angle between longitudinal axis (L) and 1st axis
11	DZ	_MID	Maximum depth infeed
12	UXY	_FAL	Finishing allowance, plane
13	UZ	_FALD	Finishing allowance, depth
14	F	_FFP1	Feedrate in the plane
15	FZ	_FFD	Depth infeed rate
16		_CDIR	Milling direction: 0 = Down-cut 1 = Up-cut
17		_VARI	Machining type
			UNITS:
			1 = Roughing 2 = Finishing 4 = Finishing of edge 5 = Chamfer
			TENS:
			0 = Predrilled, infeed with G0 1 = Vertically, infeed with G1 2 = Helically 3 = Oscillation along the pocket longitudinal axis
			HUNDREDS: Reserved
18	DXY	_MIDA	Maximum plane infeed, for unit, see _AMODE
19	L1	_AP1	Length of premachining (inc)
20	W1	_AP2	Width of premachining (inc)
21	AZ	_AD	Depth of premachining (inc)
22	ER	_RAD1	Radius of helical path on helical insertion
	EW		Maximum insertion angle for oscillation
23	EP	_DP1	Helical pitch on helical insertion
24		_UMODE	Reserved
25	FS	_FS	Chamfer width (inc)
26	ZFS	_ZFS	Insertion depth (tool tip) on chamfering (abs/inc), see _AMODE

No.	Param mask	Param internal	Explanation
27		_GMODE	Geometrical mode
			UNITS: Reserved
			TENS: Reserved
			HUNDREDS: Select machining/only calculation of start point
			0 = Compatibility mode
			1 = Normal machining
			THOUSANDS: Dimensioning via center/corner
			0 = Compatibility mode
			1 = Dimensioning via center
			2 = Dimensioning of corner point, pocket position +LENG/+WID
			3 = Dimensioning of corner point, pocket position -LENG/+WID
			4 = Dimensioning of corner point, pocket position +LENG/-WID
			5 = Dimensioning of corner point, pocket position -LENG/-WID
			TEN THOUSANDS: Complete machining/remachining
			0 = Compatibility mode (process _AP1, _AP2 and _AD as before)
			1 = Complete machining
			2 = Remachining
28		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
			TENS: Type of feedrate: G group (G94/G95) for surface and depth feedrate
			0 = Compatibility mode
			1 = G code as before cycle call. G94/G95 same for surface and depth feedrate
29		_AMODE	Alternative mode
			UNITS: Pocket depth (Z1)
			0 = Absolute (compatibility mode)
			1 = Incremental
			TENS: Unit for plane infeed (DXY)
			0 = mm
			1 = % of tool diameter
			HUNDREDS: Insertion depth for chamfering (ZFS)
			0 = Absolute
			1 = Incremental

18.1.16 Milling a circular pocket - POCKET4

Programming

```
POCKET4(REAL _RTP, REAL _RFP, REAL _SDIS, REAL _DP, REAL _CDIAM,
REAL _PA, REAL _PO, REAL _MID, REAL _FAL, REAL _FALD, REAL _FFP1,
REAL _FFD, INT _CDIR, INT _VARI, REAL _MIDA, REAL _AP1, REAL _AD,
REAL _RAD1, REAL _DP1, INT _UMODE, REAL _FS, REAL _ZFS, INT _GMODE,
INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	_RTP	Retraction plane (abs)
2	Z0	_RFP	Reference point of tool axis (abs)
3	SC	_SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	_DP	Pocket depth (abs/inc), see _AMODE
5	⌀	_DIAM	Pocket diameter or radius, see _DMODE
6	X0	_PA	Reference point 1st axis (abs)
7	Y0	_PO	Reference point 2nd axis (abs)
8	DZ	_MID	Maximum depth setting, see_VARI = by planes Maximum helical setting, see_VARI = helically
9	UXY	_FAL	Finishing allowance, plane
10	UZ	_FALD	Finishing allowance, depth
11	F	_FFP1	Feedrate for surface machining
12	FZ	_FFD	Depth infeed rate
13		_CDIR	Milling direction 0 = Down-cut 1 = Up-cut
14		_VARI	Machining type
			UNITS:
			1 = Roughing 2 = Finishing 4 = Finishing of edge 5 = Chamfer
			TENS: Infeed type (roughing and finishing)
			0 = Predrilled, infeed with G0 (pocket is premachined) 1 = Vertical, infeed with G1 2 = Helically
			HUNDRED: Reserved
			THOUSANDS:
			0 = By planes 1 = Helically
15	DXY	_MIDA	Maximum plane infeed, see _AMODE, 0 = 0.8 · tool diameter

No.	Param mask	Param internal	Explanation
16	⌀	_AP1	Diameter/radius of premachining (inc)
17	AZ	_AD	Depth of premachining (inc)
18	ER	_RAD1	Radius of helical path on helical insertion
19	EP	_DP1	Helical pitch on insertion on helical path
20		_UMODE	Reserved
21	FS	_FS	Chamfer width (inc)
22	ZFS	_ZFS	Insertion depth (tool tip) on chamfering (abs/inc), see _AMODE
23		_GMODE	Geometrical mode
			UNITS: Reserved
			TENS: Reserved
			HUNDREDS: Machining/calculation of start point
			0 = Compatibility mode
			1 = Normal machining
			THOUSANDS: Reserved
			TEN THOUSANDS: Complete machining/remachining
			0 = Compatibility mode (process _AP1 and _AD as before)
			1 = Complete machining
			2 = Remachining
24		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
			TENS: Type of feedrate: G group (G94/G95) for surface and depth feedrate
			0 = Compatibility mode
			1 = G code as before cycle call. G94/G95 same for surface and depth feedrate
			HUNDREDS:
			0 = Compatibility mode (enter _CDIAM/_AP1 as radius)
			1 = Enter _CDIAM/_AP1 as diameter
25		_AMODE	Alternative mode
			UNITS: Pocket depth (Z1)
			0 = Absolute (compatibility mode)
			1 = Incremental
			TENS: Unit for infeed width (DXY)
			0 = mm
			1 = % of tool diameter
			HUNDREDS: Insertion depth for chamfering (ZFS)
			0 = Absolute
			1 = Incremental

18.1.17 Rectangular spigot milling - CYCLE76

Programming

```
CYCLE76(REAL _RTP, REAL _RFP, REAL _SDIS, REAL _DP, REAL _DPR, REAL
_LENG, REAL _WID, REAL _CRAD, REAL _PA, REAL _PO, REAL _STA, REAL
_MID, REAL _FAL, REAL _FALD, REAL _FFP1, REAL _FFD, INT _CDIR, INT
_VARI, REAL _AP1, REAL _AP2, REAL _FS, REAL _ZFS, INT _GMODE, INT
_DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	_RTP	Retraction plane (abs)
2	Z0	_RFP	Reference point of tool axis (abs)
3	SC	_SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	_DP	Spigot depth (abs)
5		_DPR	Spigot depth (inc) with respect to Z0 (enter without sign)
6	L	_LENG	Spigot length, see _GMODE (enter without sign)
7	W	_WID	Spigot width, see _GMODE (enter without sign)
8	R	_CRAD	Spigot corner radius (enter without sign)
9	X0	_PA	Reference point for spigot in 1st axis of plane (abs)
10	Y0	_PO	Reference point for spigot in 2nd axis of plane (abs)
11	α0	_STA	Angle of rotation, angle between longitudinal axis (L) and 1st axis of plane
12	DZ	_MID	Maximum depth infeed (inc; enter without sign)
13	UXY	_FAL	Finishing allowance, plane (inc), allowance at edge contour
14	UZ	_FALD	Finishing allowance depth (inc), allowance at base (enter without sign)
15	FX	_FFP1	Feedrate on contour
16	FZ	_FFD	Depth infeed rate
17		_CDIR	Milling direction (enter without sign)
			UNITS:
			0 = Down-cut
			1 = Up-cut
18		_VARI	Machining
			UNITS:
			1 = Roughing
			2 = Finishing
			5 = Chamfer
19	L1	_AP1	Length of blank spigot
20	W1	_AP2	Width of blank spigot
21	FS	_FS	Chamfer width (inc)
22	ZFS	_ZFS	Insertion depth (tool tip) on chamfering (abs, inc), see _AMODE

No.	Param mask	Param internal	Explanation
23		_GMODE	Mode for evaluation of programmed geometrical data
			UNITS: Reserved
			TENS: Reserved
			HUNDREDS: Select machining or just calculation of start point
			0 = Compatibility mode
			1 = Normal machining
			THOUSANDS: Dimensioning of spigot acc. to center or corner
			0 = Compatibility mode
			1 = Dimensioning via center
			2 = Dimensioning of corner point, spigot +L +W
			3 = Dimensioning of corner point, spigot -L +W
			4 = Dimensioning of corner point, spigot +L -W
			5 = Dimensioning of corner point, spigot -L -W
			TEN THOUSANDS: Complete machining or remachining
			0 = Compatibility mode
			1 = Complete machining
			2 = Remachining
24		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
25		_AMODE	Alternative mode
			UNITS: Final depth Z1 (abs/inc)
			0 = Compatibility
			1 = Z1 (inc)
			2 = Z1 (abs)
			TENS: Reserved
			HUNDREDS: Insertion depth for chamfering ZFS
			0 = ZFS (abs)
			1 = ZFS (inc)

18.1.18 Circular spigot milling - CYCLE77

Programming

```
CYCLE77(REAL _RTP, REAL _RFP, REAL _SDIS, REAL _DP, REAL _DPR, REAL
_CDIAM, REAL _PA, REAL _PO, REAL _MID, REAL _FAL, REAL _FALD, REAL
_FFP1, REAL _FFD, INT _CDIR, INT _VARI, REAL _AP1, REAL _FS, REAL
_ZFS, INT _GMODE, INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	_RTP	Retraction plane (abs)
2	Z0	_RFP	Reference point of tool axis (abs)
3	SC	_SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	_DP	Spigot depth (abs)
5		_DPR	Spigot depth (inc) with respect to Z0 (enter without sign)
6	⌀	_CDIAM	Spigot diameter (enter without sign)
7	X0	_PA	Reference point for spigot in 1st axis of plane (abs)
8	Y0	_PO	Reference point for spigot in 2nd axis of plane (abs)
9	DZ	_MID	Maximum depth infeed (inc; enter without sign)
10	UXY	_FAL	Finishing allowance, plane (inc), allowance at edge contour
11	UZ	_FALD	Finishing allowance depth (inc), allowance at base (enter without sign)
12	FX	_FFP1	Feedrate on contour
13	FZ	_FFD	Depth infeed rate
14		_CDIR	Milling direction (enter without sign)
			UNITS:
			0 = Down-cut
			1 = Up-cut
15		_VARI	Machining
			UNITS:
			1 = Roughing to final machining allowance
			2 = Finishing (allowance X/Y/Z=0)
			5 = Chamfer
16	⌀1	_AP1	Diameter of blank spigot
17	FS	_FS	Chamfer width (inc)
18	ZFS	_ZFS	Insertion depth (tool tip) on chamfering (abs/inc) see _AMODE)

No.	Param mask	Param internal	Explanation
19		_GMODE	Mode for evaluation of programmed geometrical data
			UNITS: Reserved
			TENS: Reserved
			HUNDREDS: Select machining/only calculation of start point
			0 = Compatibility mode
			1 = Normal machining
			THOUSANDS: Reserved
			TEN THOUSANDS: Complete machining/remachining
			0 = Compatibility mode (process _AP1 as before)
			1 = Complete machining
			2 = Remachining
20		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the levels effective before cycle call remain active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
21		_AMODE	Alternative mode
			UNITS: Final depth Z1 (abs/inc)
			0 = Compatibility
			1 = Z1 (inc)
			2 = Z1 (abs)
			TENS: Reserved
			HUNDREDS: Insertion depth for chamfering ZFS
			0 = ZFS (abs)
			1 = ZFS (inc)

18.1.19 Multiple-edge - CYCLE79

Programming

```
CYCLE79(REAL _RTP, REAL _RFP, REAL _SDIS, REAL _DP, INT _NUM, REAL
_SWL, REAL _PA, REAL _PO, REAL _STA, REAL _RC, REAL _AP1, REAL
_MIDA, REAL _MID, REAL _FAL, REAL _FALD, REAL _FFP1, INT _CDIR, INT
_VARI, REAL _FS, REAL _ZFS, INT _GMODE, INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	_RTP	Retraction plane (abs)
2	Z0	_RFP	Reference point of tool axis (abs)
3	SC	_SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	_DP	Multiple-edge depth (abs/inc), see _AMODE
5	N	_NUM	Number of edges (1...n)
6	SW/L	_SWL	Width across flats or edge length (depending on _VARI) ("SW" for width across flats, "L" for edge length) Width across flats only if even number of edges, and single edge
7	X0	_PA	Spigot reference point, 1st axis (abs)
8	Y0	_PO	Spigot reference point, 2nd axis (abs)
9	α0	_STA	Angle of rotation, center of edge against 1st axis (X axis)
10	R1/FS1	_RC	Corner rounding with _NUM > 2 (radius/chamfer, see _AMODE) (inc, to be entered without sign) ("R1" for radius, "FS1" for chamfer)
11	⌀	_AP1	Unmachined diameter of spigot
12	DXY	_MIDA	Maximum infeed width (for unit, see _AMODE)
13	DZ	_MID	Maximum depth infeed
14	UXY	_FAL	Finishing allowance, plane
15	UZ	_FALD	Finishing allowance, depth
16	F	_FFP1	Machining feedrate
17		_CDIR	Milling direction
			0 = Down-cut
			1 = Up-cut

No.	Param mask	Param internal	Explanation
18		_VARI	Machining type
			UNITS: Machining
			1 = Roughing
			2 = Finishing
			3 = Finishing of edge
			5 = Chamfer
			TENS: Width across flats or edge length
			0 = Width across flats
			1 = Edge length
19	FS	_FS	Chamfer width (inc)
20	ZFS	_ZFS	Insertion depth (tool tip) on chamfering (abs/inc), see _AMODE)
21		_GMODE	Geometrical mode
			UNITS: Reserved
			TENS: Reserved
			HUNDREDS: Machining/calculation of start point
			1 = Normal machining
22		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
23		_AMODE	Alternative mode
			UNITS: Final depth (_DP)
			0 = Absolute
			1 = Incremental
			TENS: Unit for plane infeed (_MIDA)
			0 = mm
			1 = % of tool diameter
			HUNDREDS: Insertion depth for chamfering (_ZFS)
			0 = Absolute
			1 = Incremental
			THOUSANDS: Corner rounding (_RC)
			0 = Radius
			1 = Chamfer

18.1.20 Longitudinal slot - SLOT1

Programming

```
SLOT1 (REAL RTP, REAL RFP, REAL SDIS, REAL _DP, REAL _DPR, INT NUM,
REAL LENG, REAL WID, REAL _CPA, REAL _CPO, REAL RAD, REAL STA1, REAL
INDA, REAL FFD, REAL FFP1, REAL _MID, INT CDIR, REAL _FAL, INT VARI,
REAL _MIDF, REAL FFP2, REAL SSF, REAL _FALD, REAL _STA2, REAL _DP1,
INT _UMODE, REAL _FS, REAL _ZFS, INT _GMODE, INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	RTP	Retraction plane (abs)
2	Z0	RFP	Reference point of tool axis (abs)
3	SC	SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	_DP	Slot depth (abs)
5		_DPR	Slot depth (inc) with respect to Z0 (enter without sign)
6		NUM	Number of slots = 1
7	L	LENG	Slot length
8	W	WID	Slot width
9	X0	_CPA	Reference point in the 1st axis of the plane
10	Y0	_CPO	Reference point in the 2nd axis of the plane
11		_RAD	Reserved
12	α	STA1	Angle of rotation
13		INDA	Reserved
14	FZ	FFD	Depth infeed rate
15	F	FFP1	Feedrate
16	DZ	_MID	Maximum depth infeed
17		CDIR	Milling direction 0 = Down-cut 1 = Up-cut
18	UXY	_FAL	Finishing allowance on plane or slot edge
19		VARI	Machining type
			UNITS:
			0 = Reserved 1 = Roughing 2 = Finishing 4 = Edge finishing (only machine the edge) 5 = Chamfer
			TENS: Approach

No.	Param mask	Param internal	Explanation
			0 = Predrilled, infeed with G0 (slot is premachined)
			1 = Vertically, infeed with G1
			2 = Helically
			3 = Oscillating
			HUNDREDS: Reserved
20	DZF	MIDF	Reserved
21	FF	FFP2	Reserved
22	SF	SSF	Reserved
23	UZ	_FALD	Finishing allowance, depth
24	ER	_STA2	Radius of helical path on helical insertion
	EW		Maximum insertion angle for oscillation
25	EP	_DP1	Insertion depth per rev for helix
26		_UMODE	Reserved
27	FS	_FS	Chamfer width (inc) for chamfering
28	ZFS	_ZFS	Insertion depth (tool tip) on chamfering (abs/inc), see _AMODE)
29		_GMODE	Geometrical mode
			UNITS: Reserved
			TENS: Reserved
			HUNDREDS: Select machining or just calculation of start point
			1 = Normal machining
			THOUSANDS: Dimensioning of reference point, slot length
			0 = Center
			1 = Inner left-hand +L
			2 = Inner right-hand -L
			3 = Left-hand edge +L
			4 = Right-hand edge -L
30		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the levels effective before cycle call remain active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
			TENS: Reserved
			HUNDREDS: Reserved
			THOUSANDS: Software version identification
			1 = Functional extension SLOT1

No.	Param mask	Param internal	Explanation
31		_AMODE	Alternative mode
			UNITS: Final depth Z1 (abs/inc)
			0 = Compatibility
			1 = Z1 (inc)
			2 = Z1 (abs)
			TENS: Reserved
			HUNDREDS: Insertion depth for chamfering ZFS
			0 = ZFS (abs)
			1 = ZFS (inc)

Note

The cycle is provided with new functions that are not on earlier software versions. Consequently certain parameters in the input mask (NUM, RAD, INDA) are no longer displayed. Multiple slots on one position pattern can be programmed using "MCALL" and calling the desired position pattern, e.g. HOLES2.

18.1.21 Circumferential slot - SLOT2

Programming

```
SLOT2(REAL RTP, REAL RFP, REAL SDIS, REAL _DP, REAL _DPR, INT NUM,
REAL AFSL, REAL WID, REAL _CPA, REAL _CPO, REAL RAD, REAL STA1, REAL
INDA, REAL FFD, REAL FFP1, REAL _MID, INT CDIR, REAL _FAL, INT VARI,
REAL _MIDF, REAL FFP2, REAL SSF, REAL _FFCP, INT _UMODE, REAL _FS,
REAL _ZFS, INT _GMODE, INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	RTP	Retraction plane (abs)
2	Z0	RFP	Reference point of tool axis (abs)
3	SC	SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	_DP	Slot depth (abs)
5		_DPR	Slot depth (inc) with respect to Z0 (enter without sign)
6	N	NUM	Number of slots
7	α1	AFSL	Opening angle of the slot
8	W	WID	Slot width

No.	Param mask	Param internal	Explanation
9	X0	_CPA	Reference point = Center point of circle, 1st axis of the plane
10	Y0	_CPO	Reference point = Center point of circle, 2nd axis of the plane
11	R	RAD	Radius of the circle
12	α0	STA1	Starting angle
13	α2	INDA	Incrementing angle
14	FZ	FFD	Depth infeed rate
15	F	FFP1	Feedrate
16	DZ	_MID	Maximum depth infeed
17		CDIR	Milling direction 0 = Down-cut 1 = Up-cut
18	UXY	_FAL	Finishing allowance on plane or slot edge
19		VARI	Machining type
			UNITS:
			0 = Complete machining 1 = Roughing 2 = Finishing 3 = Finishing of edge 5 = Chamfer
			TENS:
			0 = Intermediate positioning with G0 line 1 = Intermediate positioning on circular path
			HUNDREDS: Reserved
			THOUSANDS:
			0 = Compatibility mode, if INDA = 0 then full circle, INDA <> 0 then pitch circle) 1 = Full circle 2 = Pitch circle
20	DZF	_MIDF	Reserved
21		FFP2	Reserved
22		SSF	Reserved
23	FF	_FFCP	Reserved
24		_UMODE	Reserved
25	FS	_FS	Chamfer width (inc)
26	ZFS	_ZFS	Insertion depth (tool tip) on chamfering (abs/inc), see _AMODE)
27		_GMODE	Geometrical mode
			UNITS: Reserved
			TENS: Reserved
			HUNDREDS: Select machining or just calculation of start point
			0 = Compatibility mode 1 = Normal machining

No.	Param mask	Param internal	Explanation
28		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the levels effective before cycle call remain active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
			TENS: Reserved
			HUNDREDS: Reserved
			THOUSANDS: Software version identification
			1 = SLOT2 functions as of software version 2.5
29		_AMODE	Alternative mode
			UNITS: Final depth Z1 (abs/inc)
			0 = Compatibility
			1 = Z1 (inc)
			2 = Z1 (abs)
			TENS: Reserved
			HUNDREDS: Insertion depth for chamfering ZFS
			0 = ZFS (abs)
			1 = ZFS (inc)

18.1.22 Mill open slot - CYCLE899

Programming

```
CYCLE899(REAL _RTP, REAL _RFP, REAL _SDIS, REAL _DP, REAL _LENG,
REAL _WID, REAL _PA, REAL _PO, REAL _STA, REAL _MID, REAL _MIDA,
REAL _FAL, REAL _FALD, REAL _FFP1, INT _CDIR, INT _VARI, INT _GMODE,
INT _DMODE, INT _AMODE, INT _UMODE, REAL _FS, REAL _ZFS)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	_RTP	Retraction plane (abs)
2	Z0	_RFP	Reference point of tool axis (abs)
3	SC	_SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	_DP	Slot depth (abs/inc), see _AMODE
5	L	_LENG	Length of slot (inc)
6	W	_WID	Width of slot (inc)

No.	Param mask	Param internal	Explanation
7	X0	_PA	Reference/start point 1st axis (abs)
8	Y0	_PO	Reference/start point 2nd axis (abs)
9	α0	_STA	Angle of rotation with respect to 1st axis
10	DZ	_MID	Maximum infeed depth (inc), for vortex milling only
11	DXY	_MIDA	Maximum plane infeed, see _AMODE
12	UXY	_FAL	Finishing allowance, plane
13	UZ	_FALD	Finishing allowance, depth
14	F	_FFP1	Feedrate
15		_CDIR	Milling direction
			UNITS:
			0 = Down-cut
			1 = Up-cut
			4 = Alternating
16		_VARI	Machining
			UNITS:
			1 = Roughing
			2 = Finishing
			3 = Finishing of base
			4 = Finishing of edge
			5 = Rough-finishing
			6 = Chamfer
			TENS: Reserved
			HUNDREDS: Reserved
			THOUSANDS:
			1 = Vortex milling
			2 = Plunge cutting
17		_GMODE	Evaluation of geometrical data
			UNITS: Reserved
			TENS: Reserved
			HUNDREDS: Select machining/only calculation of start point
			1 = Normal machining
			THOUSANDS: Dimensioning via center/edge
			0 = Dimensioning via center
			1 = "Left-hand" dimensioning using edge ("-" direction of 1st axis)
			2 = "Right-hand" dimensioning using edge ("+" direction of 1st axis)
18		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the levels effective before cycle call remain active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)

No.	Param mask	Param internal	Explanation
19		_AMODE	Alternative mode
			UNITS: Slot depth Z1
			0 = Absolute
			1 = Incremental
			TENS: Unit for plane infeed (_MIDA) DXY
			0 = mm
			1 = % of tool diameter
			HUNDREDS: Insertion depth for chamfering ZFS
			0 = Absolute
			1 = Incremental
20		_UMODE	Reserved
21	FS	_FS	Chamfer width (inc)
22	ZFS	_ZFS	Insertion depth (tool tip) on chamfering (abs/inc), see _AMODE)

18.1.23 Elongated hole - LONGHOLE

Programming

```
LONGHOLE (REAL RTP,REAL RFP,REAL SDIS,REAL _DP,REAL _DPR,
INT NUM,REAL LENG,REAL _CPA,REAL _CPO,REAL RAD,REAL STA1,
REAL INDA,REAL FFD,REAL FFP1,REAL MID,INT _VARI,INT _UMODE,
INT _GMODE,INT _DMODE,INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	RTP	Retraction plane (abs)
2	Z0	_RFP	Reference point of tool axis (abs)
3	SC	SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	_DP	Long hole depth (abs)
5		_DPR	Long hole depth (inc) with respect to Z0 (enter without sign)
6		NUM	Number of long holes = 1
7	L	LENG	Length of long hole
8	X0	_CPA	Reference point in the 1st axis of the plane
9	Y0	_CPO	Reference point in the 2nd axis of the plane
10		RAD	Reserved
11	α0	STA1	Angle of rotation
12		INDA	Reserved

No.	Param mask	Param internal	Explanation
13	FZ	FFD	Depth infeed rate
14	F	FFP1	Feedrate
15	DZ	MID	Maximum depth infeed
16		_VARI	Machining type
			UNITS: Infeed type
			1 = Vertically with G1
			3 = Oscillating
			HUNDRED: Reserved
17		_UMODE	Reserved
18		_GMODE	Geometrical mode
			UNITS: Reserved
			TENS: Reserved
			HUNDRED: Select machining or just calculate start point
			0 = Compatibility mode
			1 = Normal machining
			THOUSANDS: Dimensioning of reference point, slot length
			0 = Center
			1 = Inner left-hand +L
			2 = Inner right-hand -L
			3 = Left-hand edge +L
			4 = Right-hand edge -L
19		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
			TENS: Type of feedrate: G group (G94/G95) for surface and depth feedrate
			0 = Compatibility mode
			1 = G code as before cycle call. G94/G95 same for surface and depth feedrate
			HUNDREDS: Reserved
			THOUSANDS: Software version identification
			1 = Functional extension LONGHOLE (dimensioning of reference point)
20		_AMODE	Alternative mode
			UNITS: Final depth Z1 (abs/inc)
			0 = Compatibility
			1 = Z1 (inc)
			2 = Z1 (abs)

Note

The cycle is provided with new functions that are not on earlier software versions. Consequently certain parameters in the input mask (NUM, RAD, INDA) are no longer displayed. Multiple slots on one position pattern can be programmed using "MCALL" and calling the desired position pattern, e.g. HOLES2.

18.1.24 Thread milling - CYCLE70

Programming

```
CYCLE70(REAL _RTP, REAL _RFP, REAL _SDIS, REAL _DP, REAL _DIATH,
REAL _H1, REAL _FAL, REAL _PIT, INT _NT, REAL _MID, REAL _FFR, INT
_TYPTH, REAL _PA, REAL _PO, REAL _NSP, INT _VARI, INT _PITA,
STRING[15] _PITM, STRING[20] _PTAB, STRING[20] _PTABA, INT _GMODE,
INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	RP	_RTP	Retraction plane (abs)
2	Z0	_RFP	Reference point of tool axis (abs)
3	SC	_SDIS	Safety clearance (to be added to reference point, enter without sign)
4	Z1	_DP	Thread length (abs/inc), see _AMODE Take account of runout at base of hole (at least half pitch)
5	⌀	_DIATH	Nominal diameter of the thread
6	H1	_H1	Thread depth
7	U	_FAL	Finishing allowance
8	P	_PIT	Pitch (select_PITA: mm, inch, MODULE, threads/inch)
9	NT	_NT	Number of teeth on the tool tip Tool length is always with respect to bottom tooth.
10	DXY	_MID	Maximum infeed per cut _MID > _H1: all in one cut
11	F	_FFR	Milling feed
12		_TYPTH	Thread type 0 = Internal thread 1 = External thread
13	X0	_PA	Circle center 1st axis (abs)
14	Y0	_PO	Circle center 2nd axis (abs)

No.	Param mask	Param internal	Explanation
15	αS	_NSP	Start angle (multi-start thread)
16		_VARI	Machining type
			UNITS:
			1 = Roughing
			2 = Finishing
			TENS:
			1 = From top to bottom
			2 = From bottom to top
			HUNDREDS:
			0 = Right-hand thread
			1 = Left-hand thread
17		_PITA	Evaluation of thread pitch 0 = Compatibility mode 1 = Pitch in mm 2 = Pitch in threads per inch (TPI) 3 = Pitch in inches 4 = Pitch as MODULE
18		_PITM	String as marker for pitch input (for the interface only)
19		_RTAB	String for thread table ("", "ISO", "BSW", "BSP", "UNC") (for the interface only)
20		_PTABA	String for selection from thread table (e.g. "M 10", "M 12", ...) (for the interface only)
21		_GMODE	Geometrical mode
			UNITS: Reserved
			TENS: Reserved
			HUNDREDS: Machining/calculation of start point
			0 = Compatibility mode
			1 = Normal machining
22		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
23		_AMODE	Alternative mode
			UNITS: Thread length (_DP)
			0 = Absolute
			1 = Incremental

18.1.25 Engraving cycle - CYCLE60

Programming

```
CYCLE60(STRING[200] _TEXT, REAL _RTP, REAL _RFP, REAL _SDIS, REAL
_DP, REAL _DPR, REAL _PA, REAL _PO, REAL _STA, REAL _CP1, REAL _CP2,
REAL _WID, REAL _DF, REAL _FFD, REAL _FFP1, INT _VARI, INT _CODEP,
INT _UMODE, INT _GMODE, INT _DMODE, INT _AMODE)
```

Parameter

No.	Param mask	Param internal	Explanation
1		_TEXT	Text to be engraved (up to 100 characters)
2	RP	_RTP	Retraction plane (abs)
3	Z0	_RFP	Reference point of tool axis (abs)
4	SC	_SDIS	Safety clearance (to be added to the reference plane, enter without sign)
5	Z1	_DP	Depth (abs), see _AMODE
6	Z1	_DPR	Depth (inc), see _AMODE
7	X0	_PA	Reference point in 1st axis of plane (abs) - right-angled, see _VARI
	R		Reference point, length (radius) - polar, see _VARI
8	Y0	_PO	Reference point in 2nd axis of plane (abs) - right-angled, see _VARI
	α0		Reference point, angle with respect to 1st axis - polar, see _VARI
9	α1	_STA	Text direction, angle of line of text with respect to 1st axis, see _VARI
10	XM	_CP1	Center of circle of text, 1st axis of plane (abs) - right-angled, see _VARI
	LM		Center of circle of text, length (radius) with respect to WNP - polar, see _VARI
11	YM	_CP2	Center of circle of text, 2nd axis of plane (abs) - right-angled, see _VARI
	αM		Center of circle of text, angle with respect to 1st axis - polar, see _VARI
12	W	_WID	Height of characters (enter without sign)
13	DX1 DX2	_DF	Distance between characters / overall width, see _VARI
	α2		Opening angle, see _VARI
14	FZ	_FFD	Depth infeed rate, see _DMODE
15	F	_FFP1	Feedrate for surface machining
16		_VARI	Machining (alignment and reference point for engraved text)
			UNITS: Reference point
			0: Right-angled
			1: Polar
			TENS: Text alignment
			0: Text on one line
			1: Text in an upward pointing arc
			2: Text in a downward curving arc
			HUNDREDS: Reserved
			THOUSANDS: Reference point of the text, horizontal

No.	Param mask	Param internal	Explanation
			0: Left
			1: Center
			2: Right
			TEN THOUSANDS: Reference point of the text, vertical
			0: Bottom
			1: Center
			2: Top
			HUNDRED THOUSANDS: Text length
			0: Character spacing
			1: Overall text width (linear text only)
			2: Opening angle (only for circular text)
			MILLION: Circle center
			0: Right-angled (Cartesian)
			1: Polar
			TEN MILLION: Mirror writing
			0 = Compatibility
			1 = Mirror writing ON
			2 = Mirror writing OFF
17		_CODEP	Code page number for writing (currently only 1252)
18		_UMODE	Reserved
19		_GMODE	Mode for evaluation of programmed geometrical data
			UNITS: Reserved
			TENS: Reserved
			HUNDREDS: Select machining/only calculation of start point
			0 = Compatibility mode
			1 = Normal machining
20		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17
			2 = G18
			3 = G19
			TENS: Type of feedrate: G group (G94/G95) for surface and depth feedrate
			0 = Compatibility mode
			1 = G code as before cycle call. G94/G95 same for surface and depth feedrate
21		_AMODE	Alternative mode
			UNITS: Final depth (_DP,_DPR)
			0 = Compatibility
			1 = Incremental (_DPR)
			2 = Absolute (_DP)

18.1.26 Contour call - CYCLE62

Programming

```
CYCLE62(STRING[140] _KNAME, INT _TYPE, STRING[32] _LAB1, STRING[32]
_LAB2)
```

Parameters

No.	Param mask	Param internal	Explanation
1	PRG/ CON	_KNAME	Contour name or subprogram name does not have to be programmed in _TYPE = 2
2		_TYPE	Determination of contour input 0 = Subprogram 1 = Contour name 2 = Labels 3 = Labels in the subprogram
3	LAB1	_LAB1	Label 1, start of contour
4	LAB2	_LAB2	Label 2, end of contour

18.1.27 Path milling - CYCLE72

Programming

```
CYCLE72(STRING[141] _KNAME, REAL _RTP, REAL _RFP, REAL _SDIS, REAL
_DP, REAL _MID, REAL _FAL, REAL _FALD, REAL _FFP1, REAL _FFD, INT
_VARI, INT _RL, INT _AS1, REAL __LP1, REAL _FF3, INT _AS2, REAL
_LP2, INT _UMODE, REAL _FS, REAL _ZFS, INT _GMODE, INT _DMODE, INT
_AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1		_KNAME	Name of the contour subprogram
2	RP	_RTP	Retraction plane (abs)
3	Z0	_RFP	Reference point of tool axis (abs)
4	SC	_SDIS	Safety clearance (to be added to reference point, enter without sign)
5	Z1	_DP	End point, final depth (abs/inc), see _AMODE
6	DZ	_MID	Maximum depth infeed (inc; enter without sign)
7	UXY	_FAL	Finishing allowance, plane (inc), allowance at edge contour

No.	Param mask	Param internal	Explanation
8	UZ	_FALD	Finishing allowance depth (inc), allowance at base (enter without sign)
9	FX	_FFP1	Feedrate on contour
10	FZ	_FFD	Feedrate for depth infeed (or spatial infeed)
11		_VARI	Machining type
			UNITS: Machining
			1 = Roughing
			2 = Finishing
			5 = Chamfer
			TENS:
			0 = Intermediate travel with G0
			1 = Intermediate travel with G1
			HUNDREDS:
			0 = Retraction at the end of contour to reference point
			1 = Retraction at the end of contour to reference point +_SDIS
			2 = Retraction by _SDIS at the end of contour
			3 = No retraction at the end of contour, approach next start point with contour feed
			THOUSANDS: Reserved
			TEN THOUSANDS:
			0 = Machine contour forward
			1 = Machine contour backward
			Restrictions with backward machining: • Max 170 contour elements (including chamfers or rounding) • Only values in the (X/Y) and F planes are evaluated
12		_RL	Machining direction
			40 = Center of contour (G40, approach and retract: straight line or vertical)
			41 = Left of contour (G41, approach and retract: straight line or circle)
			42 = Right of contour (G42, approach and retract: straight line or circle)
13		_AS1	Contour approach movement
			UNITS:
			1 = Straight line
			2 = Quarter-circle
			3 = Semi-circle
			4 = Vertical approach and retraction
			TENS:
			0 = Last movement, in the plane
			1 = Last movement, spatial
14	L1	_LP1	Approach path or approach radius (inc; enter without sign)
15	FZ	_FF3	Feedrate for intermediate paths (G94/G95 as to contour)

No.	Param mask	Param internal	Explanation
16		_AS2	Contour approach movement (not vertical approach/retract)
			UNITS:
			1 = Straight line
			2 = Quarter-circle
			3 = Semi-circle
			TENS:
			0 = Last movement, in the plane
			1 = Last movement, spatial
17	L2	_LP2	Retract path or retract radius (inc, to be entered without sign)
18		_UMODE	Reserved
19	FS	_FS	Chamfer width (inc)
20	ZFS	_ZFS	Insertion depth (tool tip) on chamfering (abs/inc), see _AMODE
21		_GMODE	Mode for evaluation of programmed geometrical data
			UNITS: Reserved
			TENS: Reserved
			HUNDREDS: Select machining/only calculation of start point
			0 = Compatibility mode
			1 = Normal machining
22		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
			TENS: Type of feedrate: G group (G94/G95) for surface and depth feedrate
			0 = Compatibility mode
			1 = G code as before cycle call. G94/G95 same for surface and depth feedrate
			THOUSANDS:
			0 = Compatibility mode: contour name is present in _KNAME
			1 = Contour name is programmed in CYCLE62 and transferred to _SC_CONT_NAME
23		_AMODE	Alternative mode
			UNITS: End point Z1 (_DP)
			0 = Absolute (compatibility mode)
			1 = Incremental
			TENS: Units for plane infeed
			0 = mm/inch
			1 = Reserved
			HUNDREDS: Insertion depth for chamfering (_ZFS)
			0 = Absolute
			1 = Incremental

Note

If the following transfer parameters are programmed indirectly (as parameters), the input mask is not reset:

_VARI, _RL, _AS1, _AS2, _UMODE, _GMODE, _DMODE, _AMODE

18.1.28 Predrilling a contour pocket - CYCLE64

Programming

```
CYCLE64(STRING[100] _PRG, INT _VARI, REAL _RP, REAL _Z0, REAL _SC,
REAL _Z1, REAL _F, REAL _DXY, REAL _UXY, REAL _UZ, INT _CDIR,
STRING[20] _TR, INT _DR, INT _UMODE, INT _GMODE, INT _DMODE, INT
_AMODE)
```

Parameter

No.	Param mask	Param internal	Explanation
1	PRG	_PRG	Name of drilling/centering program
2		_VARI	Machining type
			UNITS: Reserved
			TENS: Reserved
			HUNDREDS: Reserved
			THOUSANDS: Lift mode
			0 = Lift off to retraction plane
			1 = Lift off to reference point + safety clearance
3	RP	_RP	Retraction plane (abs)
4	Z0	_Z0	Reference point (abs)
5	SC	_SC	Safety clearance (to be added to reference point, enter without sign)
6	Z1	_Z1	Drilling/centering depth (see _AMODE UNITS)
7	F	_F	Drilling/centering feedrate
8	DXY	_DXY	Infeed plane - unit (see AMODE TENS)
9	UXY	_UXY	Finishing allowance, plane
10	UZ	_UZ	Finishing allowance, depth
11		_CDIR	Milling direction
			0 = Down-cut
			1 = Up-cut
12	TR	_TR	Reference tool name
13	DR	_DR	Reference tool D number

No.	Param mask	Param internal	Explanation
14		_UMODE	Reserved
15		_GMODE	Mode for evaluation of programmed geometrical data
			UNITS: Reserved
			TENS: Reserved
			HUNDREDS: Select machining/only calculation of start point
			0 = Normal machining (no compatibility mode needed)
			1 = Normal machining
			2 = Reserved
25		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
			TENS: Technology mode
			1 = Predrilling
			2 = Centering
26		_AMODE	Alternative mode
			UNITS: Drilling/centering depth Z1
			0 = Absolute (compatibility mode)
			1 = Incremental
			TENS: Units for plane infeed (_DXY)
			0 = mm
			1 = % of tool diameter

18.1.29 Milling a contour pocket - CYCLE63

Programming

```
CYCLE63(STRING[100] _PRG, INT _VARI, REAL _RP, REAL _Z0, REAL _SC,
REAL _Z1, REAL _F, REAL _FZ, REAL _DXY, REAL _DZ, REAL _UXY, REAL
_UZ, INT _CDIR, REAL _XS, REAL _YS, REAL _ER, REAL _EP, REAL _EW,
REAL _FS, REAL _ZFS, STRING[20] _TR, INT _DR, INT _UMODE, INT
_GMODE, INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	PRG	_PRG	Name of removal program

No.	Param mask	Param internal	Explanation
2		_VARI	Machining type
			UNITS: Machining process
			1 = Roughing
			3 = Finishing of base
			4 = Finishing of edge
			5 = Chamfer
			TENS: Infeed type
			0 = Center insertion
			1 = Helical insertion
			2 = Oscillating insertion
			HUNDREDS: Reserved
			THOUSANDS: Lift mode
			0 = Lift off to retraction plane
			1 = Lift off to reference point + safety clearance
			TEN THOUSANDS: Start point for roughing and finishing base
			0 = Auto
			1 = Manual
3	RP	_RP	Retraction plane (abs)
4	Z0	_Z0	Reference point of tool axis (abs)
5	SC	_SC	Safety clearance (to be added to reference point, enter without sign)
6	Z1	_Z1	Final depth (see _AMODE UNITS)
7	F	_F	Feedrate in the plane during roughing/finishing
8	FZ	_FZ	Depth infeed rate
9	DXY	_DXY	Infeed plane - unit (see AMODE TENS)
10	DZ	_DZ	Depth infeed
11	UXY	_UXY	Finishing allowance, plane
12	UZ	_UZ	Finishing allowance, depth
13		_CDIR	Milling direction
			0 = Down-cut
			1 = Up-cut
14	XS	_XS	Starting point X, absolute
15	YS	_YS	Starting point Y, absolute
16	ER	_ER	Helical insertion: Radius
17	EP	_EP	Helical insertion: Pitch
18	EW	_EW	Oscillating insertion: Maximum insertion angle
19	FS	_FS	Chamfer width (inc) for chamfering
20	ZFS	_ZFS	Insertion depth of tool tip when chamfering (see AMODE HUNDREDS)
21	TR	_TR	Reference tool name when machining residual material
22	DR	_DR	Reference tool D number when machining residual material
23		_UMODE	Reserved

No.	Param mask	Param internal	Explanation
24		_GMODE	Mode for evaluation of programmed geometrical data
			UNITS: Reserved
			TENS: Reserved
			HUNDREDS: Select machining/only calculation of start point
			0 = Normal machining (no compatibility mode needed)
			1 = Normal machining
			2 = Reserved
25		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
			TENS: Reserved
			HUNDREDS: Technology mode
			1 = Pocket
			2 = Spigot
			THOUSANDS: Machine residual material
			0 = No
			1 = Yes
26		_AMODE	Alternative mode
			UNITS: Final depth Z1
			0 = Absolute (compatibility mode)
			1 = Incremental
			TENS: Units for plane infeed (_DXY)
			0 = mm
			1 = % of tool diameter
			HUNDREDS: Insertion depth for chamfering (_ZFS)
			0 = Absolute
			1 = Incremental

18.1.30 Stock removal - CYCLE951

Programming

```
CYCLE951(REAL _SPD, REAL _SPL, REAL _EPD, REAL _EPL, REAL _ZPD, REAL
_ZPL, INT _LAGE, REAL _MID, REAL _FALX, REAL _FALZ, INT _VARI, REAL
_RF1, REAL _RF2, REAL _RF3, REAL _SDIS, REAL _FF1, INT _NR, INT
_DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	X0	_SPD	Reference point (abs, always diameter)
2	Z0	_SPL	Reference point (abs)
3	X1	_EPD	End point
4	Z1	_EPL	End point
5	XM α1 α2	_ZPD	Intermediate point, see _DMODE (TENS)
6	ZM α1 α2	_ZPL	Intermediate point, see _DMODE (TENS)
7	Position	_LAGE	Position of stock removal corner 0 = External/rear 1 = External/front 2 = Internal/rear 3 = Internal/front
8	D	_MID	Maximum depth infeed on insertion
9	UX	_FALX	Finishing allowance in X
10	UZ	_FALZ	Finishing allowance in Z
11		_VARI	Machining type
			UNITS: Stock removal direction (longitudinal or transverse) in the coordinate system
			1 = Longitudinal 2 = Transverse
			TENS:
			1 = Roughing to finishing allowance 2 = Finishing
			HUNDREDS:
			0 = With rounding at the contour, without residual corners 1 = Without rounding at the contour
			THOUSANDS:
			0 = With radius/chamfer at corner 2 1 = With undercut at corner 2
			TEN THOUSANDS:
			0 = Stand still after machining 1 = Return to starting position

No.	Param mask	Param internal	Explanation
12	R1/FS1	_RF1	Rounding radius or chamfer width 1, see _AMODE (TEN THOUSANDS)
13	R2/FS2	_RF2	Rounding radius or chamfer width 2, see _AMODE (HUNDRED THOUSANDS)
14	R3/FS3	_RF3	Rounding radius or chamfer width 3, see _AMODE (ONE MILLION)
15	SC	_SDIS	Safety clearance
16	F	_FF1	Feedrate for roughing/finishing
17		_NR	Identification of stock removal type (corresponds to vertical softkey for selecting form): 0 = Stock removal 1, 90 degree corner without chamfers/rounding 1 = Stock removal 2, 90 degree corner with chamfers/rounding 2 = Stock removal 3, any corner with chamfers/rounding
18		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the plane effective before cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
			TENS: Form of input _ZPD/_ZPL
			0 = Xm/Zm 1 = Xm/α1 2 = Xm/α2 3 = α1/Zm 4 = α2/Zm 5 = α1/α2
21		_AMODE	Alternative mode
			UNITS: Intermediate point in X
			0 = Absolute, value of transverse axis in the diameter 1 = Incremental, value of transverse axis in the radius
			TENS: Intermediate point in Z
			0 = Absolute 1 = Incremental
			HUNDREDS: End point in X
			0 = Absolute, value of transverse axis in the diameter 1 = Incremental, value of transverse axis in the radius
			THOUSANDS: End point in Z.
			0 = Absolute 1 = Incremental
			TEN THOUSANDS: Radius/chamfer 1
			0 = Radius 1 = Chamfer
			HUNDRED THOUSANDS: Radius/chamfer 2
			0 = Radius 1 = Chamfer

No.	Param mask	Param internal	Explanation
			ONE MILLION: Radius/chamfer 3
			0 = Radius
			1 = Chamfer

18.1.31 Groove - CYCLE930

Programming

```
CYCLE930(REAL _SPD, REAL _SPL, REAL _WIDG, REAL _WIDG2, REAL _DIAG,
REAL _DIAG2, REAL _STA, REAL _ANG1, REAL _ANG2, REAL _RCO1, REAL
_RCI1, REAL _RCI2, REAL _RCO2, REAL _FAL, REAL _IDEP1, REAL _SDIS,
INT _VARI, INT _DN, INT _NUM, REAL _DBH, REAL _FF1, INT _NR, REAL
_FALX, REAL _FALZ, INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	X0	_SPD	Reference point in the plane axis (always diameter)
2	Z0	_SPL	Reference point along the longitudinal axis
3	B1	_WIDG	Width at bottom of groove
4	B2	_WIDG2	Width at top of groove (for interface only)
5	T1	_DIAG	Depth of groove at the reference point for abs and longitudinal machining = diameter, otherwise inc
6	T2	_DIAG2	Groove depth opposite the reference point (for interface only), for abs and longitudinal machining = diameter, otherwise inc
7	α0	_STA	Angle of inclination (-180 ≤ _STA ≤ 180)
8	α1	_ANG1	Side angle 1 (0 ≤ _ANG1 < 90) at the side of the groove determined by the reference point
9	α2	_ANG2	Side angle 2 (0 ≤ _ANG2 < 90) opposite the reference point
10	R1/FS1	_RCO1	Rounding radius or chamfer width 1, external at the reference point
11	R2/FS2	_RCI1	Rounding radius or chamfer width 2, internal at the reference point
12	R3/FS3	_RCI2	Rounding radius or chamfer width 3, internal opposite the reference point
13	R4/FS4	_RCO2	Rounding radius or chamfer width 4, external opposite the reference point
14	U	_FAL	Finishing allowance in X and Z, see _VARI (TEN THOUSANDS) (to be entered without sign)
15	D	_IDEP1	Maximum depth infeed on insertion (enter without sign) 0 = 1st cut directly to full depth > 0 = 1st cut_IDEP1, 2nd cut 2 · _IDEP1 etc.
16	SC	_SDIS	Safety clearance (enter without sign)

No.	Param mask	Param internal	Explanation
17		_VARI	Machining type
			UNITS: Reserved
			TENS: Machining process
			1 = Roughing
			2 = Finishing
			3 = Roughing and finishing
			HUNDREDS: Position longitudinal/transverse external/internal +Z/+Z and +X/-X
			1 = Longitudinal/external +Z
			2 = Transverse/internal -X
			3 = Longitudinal/internal +Z
			4 = Transverse/internal +X
			5 = Longitudinal/external -Z
			6 = Transverse/external -X
			7 = Longitudinal/internal -Z
			8 = Transverse/external +X
			THOUSANDS: Position of reference point
			0 = Upper reference point
			1 = Lower reference point
			TEN THOUSANDS: Define effect of finishing allowances
			0 = Finishing allowance U parallel to contour
			1 = Separate UX and UZ finishing allowances
18		_DN	D number for 2nd edge of tool
			> 0 = D number for correction of 2nd edge of grooving tool
			0 = No 2nd edge programmed
19	N	_NUM	Number of grooves (0 = 1 groove)
20	DP	_DBH	Distance between grooves (only needed when _NUM > 1)
21	F	_FF1	Feedrate
22		_NR	Identification for form of groove corresponds to vertical softkey for form selection
			0 = 90° sides without chamfers/rounding
			1 = Inclined sides with chamfers/rounding (without α0)
			2 = as 1, but on taper (with α0)
23	UX	_FALX	Finishing allowance in X axis, see _VARI (TEN THOUSANDS) (to be entered without sign)
24	UZ	_FALZ	Finishing allowance in z axis, see _VARI (TEN THOUSANDS) (to be entered without sign)
25		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)

No.	Param mask	Param internal	Explanation
26		_AMODE	Alternative mode
			UNITS: Dimensioning for top of groove (for interface only)
			0 = At reference point
			1 = Opposite the reference point
			TENS: Depth
			0 = Absolute
			1 = Incremental
			HUNDREDS: Dimensioning for width (for interface only)
			0 = At outer diameter (top)
			1 = At inner diameter (bottom)
			THOUSANDS: Radius/chamfer 1 (_RCO1)
			0 = Radius
			1 = Chamfer
			TEN THOUSANDS: Radius/chamfer 2 (_RCI1)
			0 = Radius
			1 = Chamfer
			HUNDRED THOUSANDS: Radius/chamfer 3 (_RCI2)
			0 = Radius
			1 = Chamfer
			MILLIONS DIGIT: Radius/chamfer 4 (_RCO2)
			0 = Radius
			1 = Chamfer

18.1.32 Undercut forms - CYCLE940

Various undercuts can be programmed using the CYCLE940 cycle. In some cases, these differ significantly regarding the parameterization.

The additional columns in the table indicate which parameters are required for which undercut type. They correspond to the vertical selection softkeys in the cycle screen form:

- E: Undercut form E
- F: Undercut form F
- A-D: DIN thread undercut (forms A-D)
- T: Thread undercut (free definition of form)

Programming

```
CYCLE940(REAL _SPD, REAL _SPL, CHAR _FORM, INT _LAGE, REAL _SDIS,
REAL _FFP,INT _VARI, REAL _EPD, REAL _EPL, REAL _R1, REAL _R2, REAL
_STA, REAL _VRT, REAL _MID, REAL _FAL, REAL _FALX, REAL _FALZ, INT
_PITI, STRING[5] _PTAB, STRING[20] _PTABA, INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Prog. for form				Explanation
			E	F	A-D	T	
1	X0	_SPD	x	x	x	x	Reference point in the plane axis (always diameter)
2	Z0	_SPL	x	x	x	x	Reference point on longitudinal axis (abs)
3	FORM	_FORM	x	x	x	x	Form of undercut (capital letters, e.g. "T") Selection, table from which the undercut values should be taken A = External, reference DIN76, A = normal B = External, reference DIN76, B = short C = Internal, reference DIN76, C = normal D = Internal, reference DIN76, D = short E = Reference DIN509 F = Reference DIN509 T = Free form
4	POSITION	_LAGE	x	x	x	x	Position of undercut (parallel Z) 0 = External +Z: ____| 1 = External -Z: |____/ 2 = Internal +Z: /-----| 3 = Internal -Z: |-----\
5	SC	_SDIS	x	x	x	x	Safety clearance (inc)
6	F	_FFP	x	x	x	x	Machining feedrate (mm/rev)
7		_VARI	-	-	x	x	Machining type UNITS: Machining 1 = Roughing 2 = Finishing 3 = Roughing + finishing TENS: Machining strategy 0 = Parallel to contour 1 = Longitudinal
			Undercut forms E and F are always machined in a single pass like finishing.				
8	X1	_EPD	x	x	-	-	Allowance X (abs/inc), see _AMODE)
			-	-	-	x	Depth of undercut (abs/inc), see _AMODE
9	Z1	_EPL	-	x	-	-	Allowance Z
			-	-	-	x	Undercut width (abs/inc), see _AMODE
10	R1	_R1	-	-	-	x	Rounding radius on slopes
11	R2	_R2	-	-	-	x	Rounding radius in the corner
12	α	_STA	-	-	x	x	Insertion angle
13	VX	_VRT	x	x	-	-	Cross-feed X (abs/inc), see _AMODE
			-	-	x	x	Cross-feed X when finishing, (abs/inc), see _AMODE
14	D	_MID	-	-	x	x	Depth infeed
15	U	_FAL	-	-	x	x	Finishing allowance parallel to contour, see _AMODE

			Prog. for form				
16	UX	_FALX	-	-	x	x	Finishing allowance X
17	UZ	_FALZ	-	-	x	x	Finishing allowance Z
18	P	_PITI	-	-	x	-	Select pitch, form A-D, corresponds to M1 ... M68
							0 = 0.20 6 = 0.50 12 = 1.25 18 = 3.50 1 = 0.25 7 = 0.60 13 = 1.50 19 = 4.00 2 = 0.30 8 = 0.70 14 = 1.75 20 = 4.50 3 = 0.35 9 = 0.75 15 = 2.00 21 = 5.00 4 = 0.40 10 = 0.80 16 = 2.50 22 = 5.50 5 = 0.45 11 = 1.00 17 = 3.00 23 = 6.00
			x	x	-	-	Select radius/depth, form E, F
							0 = 0.6 · 0.3 4 = 2.5 · 0.4 8 = 0.1 · 0.1 1 = 1.0 · 0.4 5 = 4.0 · 0.5 9 = 0.2 · 0.1 2 = 1.0 · 0.2 6 = 0.4 · 0.2 3 = 1.6 · 0.3 7 = 0.6 · 0.2
19		_PTAB					String for thread table ("", "ISO", "BSW", "BSP", "UNC") (for the interface only)
20		_PTABA					String for selection from thread table (e.g. "M 10", "M 12", ...) (for the interface only)
21		_DMODE					Display mode
			x	x	x	x	UNITS: Machining plane G17/18/19
							0 = Compatibility, the plane effective before cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
22		_AMODE					Alternative mode
			x	x	-	x	UNITS: Parameter _EPD allowance X or depth of undercut
							0 = Absolute (always diameter) 1 = Incremental
			x	x	-	x	TENS: Parameter _EPL allowance Z or width of undercut
							0 = Absolute 1 = Incremental
			x	x	x	x	HUNDREDS: Parameter _VRT cross-feed X
							0 = Absolute (always diameter) 1 = Incremental
			-	-	x	x	THOUSANDS: Finishing allowance
							0 = Finishing allowance parallel to contour (_FAL) = Separate machining allowance (_FALX/_FALZ)

18.1.33 Thread turning - CYCLE99

Programming

```
CYCLE99(REAL _SPL, REAL _SPD, REAL _FPL, REAL _FPD, REAL _APP, REAL
_ROP, REAL _TDEP, REAL _FAL, REAL _IANG, REAL _NSP, INT _NRC, INT
_NID, REAL _PIT, INT _VARI, INT _NUMTH, REAL _SDIS, REAL _MID, REAL
_GDEP, REAL _PIT1, REAL _FDEP, INT _GST, INT _GUD, REAL _IFLANK, INT
_PITA, STRING[15] _PITM, STRING[20] _PTAB, STRING[20] _PTABA, INT
_DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	Z0	_SPL	Reference point (abs)
2	X0	_SPD	Reference point (abs, always diameter)
3	Z1	_FPL	End point in conjunction with _AMODE (UNITS)
4	X1	_FPD	End point in conjunction with _AMODE (TENS)
5	LW/LW2	_APP	Thread run-in in conjunction with _AMODE (HUNDREDS) or Thread run-in = thread run-out in conjunction with _AMODE (HUNDREDS)
6	LR	_ROP	Thread run-out
7	H1	_TDEP	Thread depth
8	U	_FAL	Finishing allowance in X and Z
9	DP	_IANG	Infeed slope as a distance or an angle, in conjunction with _AMODE (THOUSANDS)
	αP		> 0 = Infeed on the positive side < 0 = Infeed on the negative side 0 = Center infeed
10	α0	_NSP	Starting angle offset (only effective with "single start")
11	ND	_NRC	Number of roughing cuts, in combination with _VARI (TEN THOUSANDS)
12	NN	_NID	Number of non-cuts
13	P	_PIT	Pitch as a value, in conjunction with _PITA
14		_VARI	Machining type
			UNITS: Technology
			1 = External thread with linear infeed 2 = Internal thread with linear infeed 3 = External thread with degressive infeed, cross-section of cut remains constant 4 = Internal thread with degressive infeed, cross-section of cut remains constant
			TENS: Reserved
			HUNDREDS: Infeed type
			1 = Infeed on one side 2 = Infeed alternate sides
			THOUSANDS: Reserved

No.	Param mask	Param internal	Explanation
			TEN THOUSANDS: Alternative depth infeed
			0 = Preset number of roughing cuts (_NRC)
			1 = Preset value for 1st infeed (_MID)
			HUNDRED THOUSANDS: Machining type
			1 = Roughing
			2 = Finishing
			3 = Roughing and finishing
			ONE MILLION: Machining sequence for multistart thread
			0 = In ascending order of threads
			1 = In descending order of threads
15	N	_NUMTH	Number of thread turns
16	VR	_SDIS	Return distance, inc
17	D1	_MID	First infeed depth, in conjunction with _VARI (TEN THOUSANDS)
18	DA	_GDEP	Thread changeover depth (only effective with "multiple start") 0 = Do not observe any thread changeover depth > 0 = Observe thread changeover depth
19	G	_PIT1	Change of pitch per revolution 0 = Pitch is constant (G33) > 0 = Pitch increases (G34) > 0 = Pitch reduces (G35)
20		_FDEP	Insertion depth (enter without sign)
21	N1	_GST	Starting thread N1 = 1...N, in conjunction with _AMODE (HUNDRED THOUSANDS)
22		_GUD	Reserved
23		_IFLANK	Infeed slope as width (for interface only)
24		_PITA	Pitch unit (evaluation of PIT and/or MPIT) 0 = Pitch in mm - MPIT/PIT evaluation 1 = Pitch in mm - PIT evaluation 2 = Pitch in TPI - evaluation of PIT (threads per inch) 3 = Pitch in inches - PIT evaluation 4 = MODULE- evaluation of PIT
25		_PITM	String as marker for pitch input (for the interface only)[1)]
26		_PTAB	String for thread table (for the interface only)[1)]
27		_PTABA	String for selection in the thread table (for the interface only)[1)]

No.	Param mask	Param internal	Explanation
28		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
			TENS: Type of thread
			0 = Longitudinal thread
			1 = Face thread
			2 = Taper thread
29		_AMODE	Alternative mode
			UNITS: Thread length in Z
			0 = Absolute
			1 = Incremental
			TENS: Thread length in X
			0 = Absolute, value of transverse axis in the diameter
			1 = Incremental, value of transverse axis in the radius
			2 = α
			HUNDREDS: Calculation of approach/run-in path _APP
			0 = Thread run-in _APP
			1 = Thread run-in = thread run-out _APP = -_ROP
			2 = Specify thread run-in path _APP = -_APP
			THOUSANDS: Select infeed slope as angle or width
			0 = Infeed angle _IANG
			1= Infeed slope _IFLANK
			TEN THOUSANDS: Single/multiple thread
			0 = Single thread (with starting angle offset _NSP)
			1 = Multiple thread
			HUNDRED THOUSANDS: Starting thread _GST
			0 = Full machining
			1 = Start machining from this thread
			2 = Only machine this thread

Note

[1)] Parameters _PITM, _PTAB and _PTABA are only used for thread selection in the input mask thread tables.
The thread tables cannot be accessed via cycle definition in the cycle run time.

18.1.34 Thread chain - CYCLE98

Programming

```
CYCLE98(REAL _PO1, REAL _DM1, REAL _PO2, REAL _DM2, REAL _PO3, REAL
_DM3, REAL _PO4, REAL _DM4, REAL APP, REAL ROP, REAL TDEP, REAL FAL,
REAL _IANG, REAL NSP, INT NRC, INT NID, REAL _PP1, REAL _PP2, REAL
_PP3, INT _VARI, INT _NUMTH, REAL _VRT, REAL _MID, REAL _GDEP, REAL
_IFLANK, INT _PITA, STRING[15] _PITM1, STRING[15] _PITM2, STRING[15]
_PITM3, INT _DMODE,INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	Z0	_PO1	Reference point in Z (abs)
2	X1	_DM1	Reference point in X (abs), in diameter
3	Z1	_PO2	Intermediate point 1 in Z (abs/inc), see _AMODE (UNITS)
4	X1	_DM2	Intermediate point 1 in X (abs/inc), see _AMODE (TENS) or
	X1α		Thread inclination 1 (-90° to 90°) abs is always diameter, inc is always radius
5	Z2	_PO3	Intermediate point 2 in Z, (abs/inc), see _AMODE (HUNDREDS)
6	X2	_DM3	Intermediate point 2 in X (abs/inc), see _AMODE (THOUSANDS) or
	X2α		Thread inclination 2 (-90° to 90°) abs is always diameter, inc is always radius
7	Z3	_PO4	End point in Z, (abs/inc), see _AMODE (TEN THOUSANDS)
8	X3	_DM4	End point in X, (abs/inc), see _AMODE (HUNDRED THOUSANDS) or
	X3α		Thread inclination 3 (-90° to 90°) abs is always diameter, inc is always radius
9	LW	APP	Thread run-in (inc, to be entered without sign)
10	LR	ROP	Thread run-out (inc, to be entered without sign)
11	H1	TDEP	Thread depth (inc, to be entered without sign)
12	U	FAL	Finishing allowance in X and Z
13	DP	_IANG	Infeed slope as a distance or an angle, see _AMODE (MILLION)
	αP		The infeed slope is applied according to the setting of parameter _VARI (HUNDREDS). Definition of _VARI_HUNDREDS = 0 - Compatibility mode: > 0 = Side infeed on one side 0 = Infeed vertical in the thread < 0 = Side infeed with alternating sides Definition for _VARI_HUNDREDS<>0: > 0 = Infeed on the positive side 0 = Center infeed < 0 = Infeed on the negative side
14	α0	NSP	Starting angle offset for the 1st thread

No.	Param mask	Param internal	Explanation
15		NRC	Number of roughing cuts, see _VARI (TEN THOUSANDS)
16	NN	NID	Number of non-cuts
17	P0	_PP1	Pitch for 1st section of thread, see _PITA
18	P1	_PP2	Pitch for 2nd section of thread, see _PITA
19	P2	_PP3	Pitch for 3rd section of thread, see _PITA
20		_VARI	Machining
			UNITS: Technology
			1 = External thread with linear infeed
			2 = Internal thread with linear infeed
			3 = External thread with degressive infeed, cross-section of cut remains constant
			4 = Internal thread with degressive infeed, cross-section of cut remains constant
			TENS: Reserved
			HUNDREDS: Infeed type
			0 = Compatibility mode for _IANG
			1 = Infeed on one side
			2 = Infeed alternate sides
			THOUSANDS: Reserved
			TEN THOUSANDS: Alternative depth infeed
			0 = Compatibility, preset number of roughing cuts (_NRC)
			1 = Preset value for 1st infeed (_MID)
			HUNDRED THOUSANDS: Machining type
			0 = Compatibility (roughing and finishing)
			1 = Roughing
			2 = Finishing
			3 = Roughing and finishing
			ONE MILLION: Machining sequence for multistart thread
			0 = In ascending order of threads
			1 = In descending order of threads
21	N	_NUMTH	Number of thread turns
22		_VRT	Return distance (inc) 0 = A lift-off distance of 1 mm is used internally regardless of the active system (inch or metric) > 0 = Lift-off distance
23	D1	_MID	First infeed, see _VARI (TEN THOUSANDS)
24	DA	_GDEP	Thread changeover depth (only effective with "multiple start") 0 = Do not observe any thread changeover depth > 0 = Observe thread changeover depth
25		_IFLANK	Infeed slope as width (for interface only)

No.	Param mask	Param internal	Explanation
26		_PITA	Evaluation of thread pitch 0 = Compatibility mode for pitch, Evaluation _PP1 to _PP3 as previously, according to active system (metric/inch) 1 = Pitch in mm 2 = Pitch in TPI (threads per inch) 3 = Pitch in inches 4 = MODULE
27		_PITM1	String as marker for pitch input (for the interface only)
28		_PITM2	String as marker for pitch input (for the interface only)
29		_PITM3	String as marker for pitch input (for the interface only)
30		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the plane effective before cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
31		_AMODE	Alternative mode
			UNITS: 1st intermediate point in Z (Z1)
			0 = Absolute 1 = Incremental
			TENS: 1st intermediate point in X (X1)
			0 = Absolute 1 = Incremental 2 = α
			HUNDREDS: 2nd intermediate point in Z (Z2)
			0 = Absolute 1 = Incremental
			THOUSANDS: 2nd intermediate point in X (X2)
			0 = Absolute 1 = Incremental 2 = α
			TEN THOUSANDS: End point in Z (Z3)
			0 = Absolute 1 = Incremental
			HUNDRED THOUSANDS: End point in X (X3)
			0 = Absolute 1 = Incremental 2 = α
			ONE MILLION: Select infeed slope as angle or width
			0 = Infeed angle _IANG 1= Infeed slope _IFLANK

No.	Param mask	Param internal	Explanation
			TEN MILLIONS: Single/multiple thread
			0 = Compatibility mode (starting angle _NSP is evaluated)
			1 = Single thread (with starting angle offset _NSP)
			2 = Multiple thread

18.1.35 Cut-off - CYCLE92

Programming

```
CYCLE92(REAL _SPD, REAL _SPL, REAL _DIAG1, REAL _DIAG2, REAL _RC,
REAL _SDIS, REAL _SV1, REAL _SV2, INT _SDAC, REAL _FF1, REAL _FF2,
REAL _SS2, REAL _DIAGM, INT _VARI, INT _DN, INT _DMODE, INT _AMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	X0	_SPD	Reference point (abs, always diameter)
2	Y0	_SPL	Reference point (abs)
3	X1	_DIAG1	Depth for speed reduction, see _AMODE (UNITS)
4	X2	_DIAG2	Final depth, see _AMODE (TENS)
5	R/FS	_RC	Rounding status or chamfer width, see _AMODE (THOUSANDS)
6	SC	_SDIS	Safety clearance (to be added to reference point, enter without sign)
7	S	_SV1	Constant spindle speed, see _AMODE (TEN THOUSANDS)
	V		Constant cutting rate
8	SV	_SV2	Maximum speed at constant cutting speed
9	DIR	_SDAC	Direction of spindle rotation
			3 = for M3
			4 = for M4
10	F	_FF1	Infeed as far as depth for speed reduction
11	FR	_FF2	Reduced infeed as far as final depth
12	SR	_SS2	Reduced speed as far as final depth
13	XM	_DIAGM	Depth to withdraw parts gripper (abs, always diameter)
14		_VARI	Machining type
			UNITS: Retraction
			0 = Retraction to _SPD+_SDIS
			1 = No retraction at the end
			TENS: Parts gripper
			0 = No, do not execute M command
			1 = Yes, call from CUST_TECHCYC(101)- open drawer, CUST_TECHCYC(102)- close drawer

No.	Param mask	Param internal	Explanation
15		_DN	D number for 2nd edge of tool; if not programmed ⇒ D+1
20		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
21		_AMODE	Alternative mode
			UNITS: Depth for speed reduction (_DIAG1)
			0 = Absolute, value of transverse axis in the diameter
			1 = Incremental, value of transverse axis in the radius
			TENS: Final depth (_DIAG2)
			0 = Absolute, value of transverse axis in the diameter
			1 = Incremental, value of transverse axis in the radius
			HUNDREDS: Reserved
			THOUSANDS: Radius/chamfer (_RC)
			0 = Radius
			1 = Chamfer
			TEN THOUSANDS: Spindle speed/ cutting rate (_SV1)
			0 = Constant spindle speed
			1 = Constant cutting rate

18.1.36 Contour cutting - CYCLE95

Programming

```
CYCLE95(STRING[140] NPP, REAL MID, REAL FALZ, REAL FALX, REAL FAL,
REAL FF1, REAL FF2, REAL FF3, INT VARI, REAL DT, REAL DAM, REAL
_VRT, INT _GMODE, INT _DMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1	CON	NPP	Contour name
2	D	MID	Maximum depth infeed during roughing, see _GMODE
3	UZ	FALZ	Finishing allowance in Z
4	UX	FALX	Finishing allowance in X
5	U	FAL	Finishing allowance parallel to contour (effective in both axes)

No.	Param mask	Param internal	Explanation
6	F	FF1	Feedrate for roughing
7	FY	FF2	Insertion feedrate, relief cuts
8	FS	FF3	Finishing feedrate
9		VARI	Machining type
			UNITS and TENS:
			1 = Roughing, longitudinal, external
			2 = Roughing, transverse, external
			3 = Roughing, longitudinal, internal
			4 = Roughing, transverse, internal
			5 = Finishing, longitudinal, external
			6 = Finishing, transverse, external
			7 = Finishing, longitudinal, internal
			8 = Finishing, transverse, internal
			9 = Complete machining, longitudinal, external
			10 = Complete machining, transverse, external
			11 = Complete machining, longitudinal, internal
			12 = Complete machining, transverse, internal
			HUNDREDS:
			0 = With rounding at the contour, without residual corners
			1 = Without rounding at the contour
			2 = Rounding only to previous intersection, residual corners can result
10	DT	DT	Dwell time at feed interruption
11	DI	DAM	Distance for feed interruptions
12	VRT	_VRT	Lift-off distance from the contour
			0 = A lift-off distance of 1 mm is used internally regardless of the active system (inch or metric)
			> 0 = Lift-off distance
13		_GMODE	Geometrical mode (evaluation of programmed geometrical data)
			UNITS: Evaluation of the infeed depth
			0 = Infeed depth is calculated corresponding to the G group DIAMON/DIAMOF
			1 = Infeed depth acts as radius value (independent of DIAMON/DIAMOF)
14		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)
			THOUSANDS:
			0 = Compatibility mode: Contour name is in NPP
			1 = Contour name is programmed in CYCLE62 and transferred to _SC_CONT_NAME

18.1.37 Contour grooving - CYCLE952

Programming

```
CYCLE952(STRING[100] _PRG, STRING[100] _CON, STRING[100] _CONR, INT
_VARI, REAL _F, REAL _FR, REAL _RP, REAL _D, REAL _DX, REAL _DZ,
REAL _UX, REAL _UZ, REAL _U, REAL _U1, INT _BL, REAL _XD, REAL _ZD,
REAL _XA, REAL _ZA, REAL _XB, REAL _ZB, REAL _XDA, REAL _XDB, INT
_N, REAL _DP, REAL _DI, REAL _SC, INT _DN, INT _GMODE, INT _DMODE,
INT _AMODE, INT _PK, REAL _DCH)
```

Parameters

No.	Param mask	Param internal	Explanation
1	PRG	_PRG	Name of the stock removal program
2	CON	_CON	Name of the program from which the updated contour of the blank is read (for residual machining)
3	CONR	_CONR	Name of the program into which the updated contour for the blank (see _AMODE TEN THOUSANDS) will be written
4		_VARI	Machining type
			UNITS: Type of stock removal
			1 = Longitudinal
			2 = Transverse
			3 = Parallel to contour
			TENS: Machining process (see _GMODE HUNDREDS)
			1 = Roughing
			2 = Finishing
			3 = Reserved
			4 = Roughing, two-channel
			5 = Finishing, two-channel
			HUNDREDS: Machining direction
			1 = Machining direction X -
			2 = Machining direction X +
			3 = Machining direction Z -
			4 = Machining direction Z +
			THOUSANDS: Infeed direction
			1 = Externally X-
			2 = Internally X +
			3 = Front face Z -
			4 = Rear face Z +
			TEN THOUSANDS: Define effect of finishing allowances
			0 = Separate UX and UZ finishing allowances
			1 = Finishing allowance U parallel to contour

No.	Param mask	Param internal	Explanation
			HUNDRED THOUSANDS: Rounding
			0 = Compatibility, automatic rounding
			1 = With rounding at the contour
			2 = Without rounding
			3 = Automatic rounding
			ONE MILLION: Relief cuts
			0 = Position is not evaluated during grooving, - residual and groove turning, - remainder
			1 = Machine relief cuts
			2 = No machining of relief cuts
			TEN MILLION: Behind/in front of turning center
			0 = Machining in front of the turning center
			1 = Reserved
5	F	_F	Feedrate for roughing/finishing
	FZ		Infeed abscissa groove turning
6	FR	_FR	Feedrate for insertion into relief cuts, roughing
	FX		Infeed ordinate groove turning
7	RP	_RP	Retraction plane for internal machining (abs., always diameter)
8	D	_D	Roughing infeed (see _AMODE UNITS)
9	DX	_DX	X infeed (see _AMODE UNITS)
10	DZ	_DZ	Z infeed (see _AMODE UNITS)
11	UX	_UX	Finishing allowance X, (see _VARI TEN THOUSANDS)
12	UZ	_UZ	Finishing allowance Z, (see _VARI TEN THOUSANDS)
13	U	_U	Finishing allowance parallel to contour, (see _VARI TEN THOUSANDS)
14	U1	_U1	Additional finishing allowance while finishing (see_AMODE THOUSANDS)
15	BL	_BL	Definition of blank
			1 = Cylinder with allowance
			2 = Allowance at contour of finished part
			3 = Contour of blank is given
16	XD	_XD	Definition of blank X (see _AMODE HUNDRED THOUSANDS)
17	ZD	_ZD	Definition of blank Z (see _AMODE MILLION)
18	XA	_XA	Limit 1 X (abs., always diameter)
19	ZA	_ZA	Limit 1 Z (abs.)
20	XB	_XB	Limit 2 X (see _AMODE TEN MILLION)
21	ZB	_ZB	Limit 2 Z (see _AMODE HUNDRED MILLION)
22	XDA	_XDA	Grooving limit 1 for the 1st groove position on the front face (abs., always diameter)
23	XDB	_XDB	Grooving limit 2 for the 1st groove position on the front face (abs., always diameter)
24	N	_N	Number of grooves
25	DP	_DP	Distance between grooves
			Longitudinal groove: Parallel to Z axis
			Transverse groove: Parallel to X axis

No.	Param mask	Param internal	Explanation
26	DI	_DI	Distance for interruption of infeed 0 = No interruption > 0 = With interruption
27	SC	_SC	Safety clearance for avoiding obstacles, incremental
28	D2	_DN	D number for 2nd edge of tool; if not programmed ⇒ D+1
29		_GMODE	Geometrical mode (evaluation of programmed geometrical data)
			UNITS: Reserved
			TENS: Reserved
			HUNDREDS: Select machining/only calculation of start point
			0 = Normal machining (no compatibility mode needed) 1 = Normal machining 2 = Calculate start point - no machining (only for call from ShopMill/ShopTurn)
			THOUSANDS: Limit
			0 = No 1 = Yes
			TEN THOUSANDS: Enter limit 1 X
			0 = No 1 = Yes
			HUNDRED THOUSANDS: Enter limit 2 X
			0 = No 1 = Yes
			ONE MILLION: Enter limit 1 Z
			0 = No 1 = Yes
			TEN MILLION: Enter limit 2 Z
			0 = No 1 = Yes
30		_DMODE	Display mode
			UNITS: Machining plane G17/18/19
			0 = Compatibility, the plane effective before cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
			TENS: Technology mode
			1 = Contour cutting 2 = Contour grooving 3 = Groove turning
			HUNDREDS: Machine residual material
			0 = No 1 = Yes

No.	Param mask	Param internal	Explanation
31		_AMODE	Alternative mode
			UNITS: Select infeed
			0 = DX and DZ infeed for stock removal parallel to contour
			1 = D infeed
			TENS: Infeed strategy
			0 = Variable cutting depth (90 ... 100%)
			1 = Constant cutting depth
			HUNDREDS: Cut segmentation
			0 = Uniform
			1 = Align to edges
			THOUSANDS: Select contour allowance U1, double finishing
			0 = No
			1 = Yes
			TEN THOUSANDS: Update selection of blank
			0 = No
			1 = Yes
			HUNDRED THOUSANDS: Select allowance on blank XD
			0 = Absolute, value of transverse axis in the diameter
			1 = Incremental, value of transverse axis in the radius
			ONE MILLION: Select allowance on blank ZD
			0 = Absolute
			1 = Incremental
			TEN MILLION: Select limit 2 XB
			0 = Absolute, value of transverse axis in the diameter
			1 = Incremental, value of transverse axis in the radius
			HUNDRED MILLION: Select limit 2 ZB
			0 = Absolute
			1 = Incremental
			BILLION
			0 = Leading channel
			1 = Following channel
32		_PK	Number of the partner channel if there are more than two channels available at the machine.
33	DCH	_DCH	Channel offset

18.1.38 Swiveling - CYCLE800

Programming

```
CYCLE800(INT _FR, STRING[32] _TC, INT _ST, INT _MODE, REAL _X0, REAL
_Y0, REAL _Z0, REAL _A, REAL _B, REAL _C, REAL _X1, REAL _Y1, REAL
_Z1, INT _DIR, REAL _FR_I, INT _DMODE)
```

Parameters

No.	Param mask	Param internal	Explanation
1		_FR	Retraction mode:
			0 = No retraction
			1 = Retraction machine axis Z
			2 = Retraction machine axis Z and then XY
			3 = Reserved
			4 = Maximum retraction in tool direction
			5 = Incremental retraction in tool direction
2		_TC	Name of swivel data record:
			"" "" (no name) if only one swivel data record exists
			"0" Deselect swivel data record (delete the swivel frames)
3		_ST	Status transformations
			UNITS:
			0 = New, swivel level is deleted and recalculated using the current parameters
			1 = Additive, swivel level is added to active swivel level
			TENS: Replace tool tip yes/no (only active when IBN SWIVEL function is set up)
			0 = Do not replace tool tip
			1 = Replace tool tip (TRAORI)
			HUNDREDS: Approach/align tool (function is shown in tool swivel input mask)
			0 = Do not approach tool
			1 = Approach tool (preferably radial mill)
			2 = Align turning tool (when B axis kinematic is set up for milling in IBN swiveling)
			3 = Align milling tool (when B axis kinematic is set up for milling in IBN swiveling)
			9 = Reserved
			THOUSANDS: Internal "Swiveling in JOG" parameter
			TEN THOUSANDS: See direction parameter _DIR
			0 = Swivel "yes"
			1 = Swivel "no", "minus" direction[3)]
			2 = Swivel "no", "plus" direction[3)]
			HUNDRED THOUSANDS: See direction parameter _DIR
			0 = Compatibility
			1 = Direction selection "Minus" optimized[4)]
			2 = Direction selection "Plus" optimized[4)]

No.	Param mask	Param internal	Explanation
4		_MODE 5)	Swivel mode: Evaluation of swivel angle and swivel sequence (bit-coded)
			Bit: 7 6
			0 0: Swivel angle by axis -> see parameters _A, _B, _C
			0 1: Solid angle -> see parameters _A, _B1)
			1 0: Projection angle -> see parameters _A, _B _C 1)
			1 1: Direct rotary axis swivel mode -> see parameters _A, _B1)
			Bit: 5 4 3 2 1 0 (these do not apply to solid angles)
			x x x x 0 1 1st rotation _A around X
			x x x x 1 0 1st rotation _A around Y
			x x x x 1 1 1st rotation _A around Z
			x x 0 1 x x 2nd rotation _B around X
			x x 1 0 x x 2nd rotation _B around Y
			x x 1 1 x x 2nd rotation _B around Z
			0 1 x x x x 3rd rotation _C around X
			1 0 x x x x 3rd rotation _C around Y
			1 1 x x x x 3rd rotation _C around Z
5	X0	_X0	Reference point X prior to rotation
6	Y0	_Y0	Reference point Y prior to rotation
7	Z0	_Z0	Reference point Z prior to rotation
8	X(A)	_A	1st rotation acc. to setting in _MODE parameter
9	Y(B)	_B	2nd rotation acc. to setting in _MODE parameter
10	Z(C)	_C	3rd rotation acc. to setting in _MODE parameter
11	X1	_X1	Reference point X after rotation
12	Y1	_Y1	Reference point Y after rotation
13	Z1	_Z1	Reference point Z after rotation
14	- or +	_DIR	Initiate travel of rotary axes (default = -1!):
			-1 = Position at smaller value of rotary axis 1 or 2 2)
			+1 = Position at larger value of rotary axis 1 or 2 2)
			0 = Do not swivel (merely calculate swivel frame) 1) 3)
15	FR	_FR_I	Value (inc) of retraction in tool direction incremental
16		_DMODE	Display mode
			UNITS: Machining plane G17/G18/G19
			0 = Compatibility, the plane effective before cycle call remains active
			1 = G17 (only active in the cycle)
			2 = G18 (only active in the cycle)
			3 = G19 (only active in the cycle)

Note

If the following transfer parameters are programmed indirectly (as parameters), the input mask is not reset: _FR, _ST, _TC, _MODE, _DIR

[1] Can be selected when function is set up in IBN SWIVEL

[2] Can be selected if direction reference to rotary axis 1 or 2 is set in IBN SWIVEL

If direction reference is "no" there is no selection field

[3] Swivel selection "no" can be grayed out SD 55221 Bit 0

Swivel "no", "minus" direction corresponds to _DIR = 0 and _ST TEN THOUSANDS = 1

Swivel "no", "plus" direction corresponds to _DIR = 0 and _ST TEN THOUSANDS = 2

[4] The direction selection for rotary axis 1 or 2 also occurs if the rotary axis with the direction reference is in the pole position (position value equals zero).

[5] Coding example: Axis-by-axis rotation, rotary sequence ZYX

Binary: 00011011 Decimal: 27

The axis identifiers XYZ correspond to the geometry axes of the NC channel. Individual rotations around the XYZ axes are permissible. Example: rotary sequence around ZXZ is not permitted in one call of CYCLE800.

18.1.39 High Speed Settings - CYCLE832

Programming

```
CYCLE832(REAL S_TOL, INT S_TOLM, REAL S_OTOL)
```

Note

CYCLE832 does not relieve the machine manufacturer from optimization tasks that are necessary when commissioning the machine. This involves the optimization of the axes involved in the machining process and NCU settings (pre-control, jerk limiting, etc.).

Parameters

No.	Param mask	Param internal	Explanation
1	Toler-ance	S_TOL	Contour tolerance The contour tolerance corresponds to the axis tolerance of the geometry axes.

No.	Param mask	Param internal	Explanation
2		S_TOLM	Machining type (technology)
			UNITS:
			0 = Deselection 1 = Finishing 2 = Semi-finishing 3 = Roughing
			TENS:
			0 = Compatibility[1] or no orientation tolerance 1 = Orientation tolerance in the 3rd parameter
			To improve the readability of the cycle call, the "Machining mode" parameter can also be entered in plain text. Plain texts are not language-dependent. The following entries are permitted:
			_FINISH = Finishing _SEMIFIN = Semi-finishing _ROUGH = Roughing _ORI_FINISH = Finishing with input of an orientation tolerance _ORI_SEMIFIN = Semi-finishing with input of an orientation tolerance _ORI_ROUGH = Roughing with input of an orientation tolerance OFF = Deselection
			Note: The terms are based on the G function group 59 (dynamic response mode for path interpolation). With these plain texts, 3-axis machines and machines with multi-axis orientation transformation (TRAORI) are clearly separated in the application.
3	ORI tolerance	S_OTOL	Orientation tolerance or version identifier CYCLE832 Tolerance parameter for the orientation of the workpiece. Is required when executing a high-speed machining program on machines with dynamic orientation transformation (e.g. 5-axis machining). Parameter S_OTOL **must** be programmed. This also applies for applications on 3-axis machines for programs without orientation of the tool (S_OTOL = 1).

[1] Orientation tolerance derived from of the contour tolerance multiplied by the factor from the cycle setting data SD55441 to SD55443.
References:
Commissioning Manual, Base Software and Operator Software; SINUMERIK Operate (IM9), Section "Configuring the High Speed Settings function (CYCLE832)"

Note

When CYCLE832 is deselected, parameter S_TOL must be transferred with zero.

Example: `CYCLE832(0,0,1)`

The syntax `CYCLE832()` is also permitted for deselecting CYCLE832.

Examples

Example 1: CYCLE832 on 3-axis machine without orientation transformation

a) Cycle call with plain text input

Program code	Comment
G710	; Dimension system is metric.
CYCLE832(0.004,_FINISH,1)	; CYCLE832 call with: Contour tolerance = 0.004 mm, machining type: Finishing
...	; Execution of a high-speed machining program

b) Cycle call without plain text input

Program code	Comment
G710	; See above.
CYCLE832(0.004,1,1)	; See above.
...	; See above.

Example 2: CYCLE832 on 5-axis machine with orientation transformation

a) Cycle call and deselection with plain text input

Program code	Comment
G710	; Dimension system is metric.
TRAORI	; Activate orientation transformation.
CYCLE832(0.3,_ORI_ROUGH,0.8)	; CYCLE832 call with: Contour tolerance = 0.3 mm, machining type: Roughing with input of an orientation tolerance; orientation tolerance = 0.8 degrees
...	; Execution of a high-speed machining program
CYCLE832(0,_OFF,1)	; Contour tolerance = 0, machining type: Deselection of CYCLE832, orientation tolerance = 0 degrees

b) Cycle call and deselection without plain text input

Program code	Comment
G710	; See above.
TRAORI	; See above.
CYCLE832(0.3,13,0.8)	; See above.
...	; See above.
CYCLE832(0,0,1)	; See above.

Tables

19

19.1 Operations

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
:	O	NC main block number, jump label termination, concatenation operator		+		*PGAsl* Arithmetic functions (Page 69)
*	O	Operator for multiplication		+		*PGAsl* Arithmetic functions (Page 69)
+	O	Operator for addition		+		*PGAsl* Arithmetic functions (Page 69)
-	O	Operator for subtraction		+		*PGAsl* Arithmetic functions (Page 69)
<	O	Comparison operator, less than		+		*PGAsl* Arithmetic functions (Page 69)
<<	O	Concatenation operator for strings		+		*PGAsl* Arithmetic functions (Page 69)
<=	O	Comparison operator, less than or equal to		+		*PGAsl* Arithmetic functions (Page 69)
=	O	Assignment operator		+		*PGAsl* Arithmetic functions (Page 69)
>=	O	Comparison operator, greater than or equal to		+		*PGAsl* Arithmetic functions (Page 69)
/	O	Operator for division		+		*PGAsl* Arithmetic functions (Page 69)
/0 … … /7		Block is skipped (1st skip level) Block is skipped (8th skip level)		+		*PGsl*
A	A	Axis name	m/s	+		*PGAsl* Programming the tool orientation (A..., B..., C..., LEAD, TILT) (Page 313)
A2	A	Tool orientation: RPY or Euler angle	s	+		*PGAsl* Programming the tool orientation (A..., B..., C..., LEAD, TILT) (Page 313)
A3	A	Tool orientation: Direction/surface normal vector component	s	+		*PGAsl* Programming the tool orientation (A..., B..., C..., LEAD, TILT) (Page 313)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
A4	A	Tool orientation: Surface normal vector for beginning of block	s	+		*PGAsl* Face milling (A4, B4, C4, A5, B5, C5) (Page 319)
A5	A	Tool orientation: Surface normal vector for end of block	s	+		*PGAsl* Face milling (A4, B4, C4, A5, B5, C5) (Page 319)
ABS	F	Absolute value (amount)		+	+	*PGAsl* Arithmetic functions (Page 69)
AC	K	Absolute dimensions of coordinates/positions	s	+		*PGsl*
ACC	K	Effect of current axial acceleration	m	+	+	*PGsl*
ACCLIMA	K	Effect of current maximum axial acceleration	m	+	+	*PGAsl* Influence of acceleration on following axes (VELOLIMA, ACCLIMA, JERKLIMA) (Page 459)
ACN	K	Absolute dimensions for rotary axes, approach position in negative direction	s	+		*PGsl*
ACOS	F	Arc cosine (trigon. function)		+	+	*PGAsl* Arithmetic functions (Page 69)
ACP	K	Absolute dimensions for rotary axes, approach position in positive direction	s	+		*PGsl*
ACTBLOCNO	P	Output of current block number of an alarm block, even if "current block display suppressed" (DISPLOF) is active!		+		*PGAsl* Suppress current block display (DISPLOF, DISPLON, ACTBLOCNO) (Page 172)
ADDFRAME	F	Inclusion and possible activation of a measured frame		+	-	*PGAsl, FB1sl (K2)* Frame calculation from three measuring points in space (MEAFRAME) (Page 288)
ADIS	A	Rounding clearance for path functions G1, G2, G3, ...	m	+		*PGsl*
ADISPOS	A	Rounding clearance for rapid traverse G0	m	+		*PGsl*
ADISPOSA	P	Size of the tolerance window for IPOBRKA	m	+	+	*PGAsl* Programmable end of motion criteria (FINEA, COARSEA, IPOENDA, IPOBRKA, ADISPOSA) (Page 268)
ALF	A	LIFTFAST angle	m	+		*PGAsl* Fast retraction from the contour (SETINT LIFTFAST, ALF) (Page 127)
AMIRROR	G	Programmable mirroring	s	+		*PGsl*
AND	K	Logical AND		+		*PGAsl* Comparison and logic operations (Page 71)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
ANG	A	Contour angle	s	+		*PGsl*
AP	A	Polar angle	m/s	+		*PGsl*
APR	K	Read/show access protection		+		*PGAsl* Attribute: Access rights (APR, APW, APRP, APWP, APRB, APWB) (Page 39)
APRB	K	Read access right, OPI		+		*PGAsl* Attribute: Access rights (APR, APW, APRP, APWP, APRB, APWB) (Page 39)
APRP	K	Read access right, part program		+		*PGAsl* Attribute: Access rights (APR, APW, APRP, APWP, APRB, APWB) (Page 39)
APW	K	Write access protection		+		*PGAsl* Attribute: Access rights (APR, APW, APRP, APWP, APRB, APWB) (Page 39)
APWB	K	Write access right, OPI		+		*PGAsl* Attribute: Access rights (APR, APW, APRP, APWP, APRB, APWB) (Page 39)
APWP	K	Write access right, part program		+		*PGAsl* Attribute: Access rights (APR, APW, APRP, APWP, APRB, APWB) (Page 39)
APX	K	Definition of the access right for executing the specified language element		+		*PGAsl* Redefinition of system variables, user variables, and NC language commands (REDEF) (Page 29)
AR	A	Opening angle	m/s	+		*PGsl*
AROT	G	Programmable rotation	s	+		*PGsl*
AROTS	G	Programmable frame rotations with solid angles	s	+		*PGsl*
AS	K	Macro definition		+		*PGAsl* Macro technique (DEFINE ... AS) (Page 205)
ASCALE	G	Programmable scaling	s	+		*PGsl*
ASIN	F	Arithmetic function, arc sine		+	+	*PGAsl* Arithmetic functions (Page 69)
ASPLINE	G	Akima spline	m	+		*PGAsl* Spline interpolation (ASPLINE, BSPLINE, CSPLINE, BAUTO, BNAT, BTAN, EAUTO, ENAT, ETAN, PW, SD, PL) (Page 230)
ATAN2	F	Arc tangent 2		+	+	*PGAsl* Arithmetic functions (Page 69)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
ATOL	K	Axis-specific tolerance for compressor functions, orientation smoothing and smoothing types		+		*PGAs/* Programmable contour/orientation tolerance (CTOL, OTOL, ATOL) (Page 488)
ATRANS	G	Additive programmable translation	s	+		*PGs/*
AUXFUDEL	P	Delete auxiliary function channel-specifically from the global list		+	-	*FB1s/ (H2)*
AUXFUDELG	P	Delete all auxiliary functions of an auxiliary function group channel-specifically from the global list		+	-	*FB1s/ (H2)*
AUXFUMSEQ	P	Determine output sequence of M auxiliary functions		+	-	*FB1s/ (H2)*
AUXFUSYNC	P	Generate a complete part program block for the channel-specific SERUPRO end ASUB as string from the global list of auxiliary functions		+	-	*FB1s/ (H2)*
AX	K	Variable axis identifier	m/s	+		*PGAs/* Axis functions (AXNAME, AX, SPI, AXTOSPI, ISAXIS, AXSTRING, MODAXVAL) (Page 583)
AXCTSWE	P	Rotate axis container		+	-	*PGAs/* Axis container (AXCTSWE, AXCTSWED, AXCTSWEC) (Page 590)
AXCTSWEC	P	Canceling enable for axis container rotation		+	+	*PGAs/* Axis container (AXCTSWE, AXCTSWED, AXCTSWEC) (Page 590)
AXCTSWED	P	Rotating axis container (command variant for commissioning!)		+	-	*PGAs/* Axis container (AXCTSWE, AXCTSWED, AXCTSWEC) (Page 590)
AXIS	K	Axis identifier, axis address		+		*PGAs/* Definition of user variables (DEF) (Page 24)
AXNAME	F	Converts input string into axis identifier		+	-	*PGAs/* Axis functions (AXNAME, AX, SPI, AXTOSPI, ISAXIS, AXSTRING, MODAXVAL) (Page 583)
AXSTRING	F	Converts string spindle number		+	-	*PGAs/* Axis functions (AXNAME, AX, SPI, AXTOSPI, ISAXIS, AXSTRING, MODAXVAL) (Page 583)
AXTOCHAN	P	Request axis for a specific channel. Possible from NC program and synchronized action.		+	+	*PGAs/* Transfer axis to another channel (AXTOCHAN) (Page 137)
AXTOINT	F	Converting a data type of an axis variable from AXIS to INT		+	-	*PGAs/* Explicit data type conversions (AXTOINT, INTTOAX) (Page 53)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
AXTOSPI	F	Converts axis identifier into a spindle index		+	-	*PGAsl* Axis functions (AXNAME, AX, SPI, AXTOSPI, ISAXIS, AXSTRING, MODAXVAL) (Page 583)
B	A	Axis name	m/s	+		*PGAsl* Programming the tool orientation (A..., B..., C..., LEAD, TILT) (Page 313)
B2	A	Tool orientation: RPY or Euler angle	s	+		*PGAsl* Programming the tool orientation (A..., B..., C..., LEAD, TILT) (Page 313)
B3	A	Tool orientation: Direction/surface normal vector component	s	+		*PGAsl* Programming the tool orientation (A..., B..., C..., LEAD, TILT) (Page 313)
B4	A	Tool orientation: Surface normal vector for beginning of block	s	+		*PGAsl* Face milling (A4, B4, C4, A5, B5, C5) (Page 319)
B5	A	Tool orientation: Surface normal vector for end of block	s	+		*PGAsl* Face milling (A4, B4, C4, A5, B5, C5) (Page 319)
B_AND	O	Bit-by-bit AND		+		*PGAsl* Comparison and logic operations (Page 71)
B_OR	O	Bit-by-bit OR		+		*PGAsl* Comparison and logic operations (Page 71)
B_NOT	O	Bit-by-bit negation		+		*PGAsl* Comparison and logic operations (Page 71)
B_XOR	O	Bit-by-bit exclusive OR		+		*PGAsl* Comparison and logic operations (Page 71)
BAUTO	G	Definition of the first spline section by means of the next 3 points	m	+		*PGAsl* Spline interpolation (ASPLINE, BSPLINE, CSPLINE, BAUTO, BNAT, BTAN, EAUTO, ENAT, ETAN, PW, SD, PL) (Page 230)
BLOCK	K	Together with the keyword TO defines the program part to be processed in an indirect subprogram call		+		*PGAsl* Indirect subprogram call with specification of the calling program part (CALL BLOCK ... TO ...) (Page 194)
BLSYNC	K	Processing of interrupt routine is only to start with the next block change		+		*PGAsl* Assign and start interrupt routine (SETINT, PRIO, BLSYNC) (Page 124)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
BNAT [6]	G	Natural transition to first spline block	m	+		*PGAs*/ Spline interpolation (ASPLINE, BSPLINE, CSPLINE, BAUTO, BNAT, BTAN, EAUTO, ENAT, ETAN, PW, SD, PL) (Page 230)
BOOL	K	Data type: Boolean value TRUE/FALSE or 1/0		+		*PGAs*/ Definition of user variables (DEF) (Page 24)
BOUND	F	Tests whether the value falls within the defined value range. If the values are equal, the test value is returned.		+	+	*PGAs*/ Variable minimum, maximum and range (MINVAL, MAXVAL and BOUND) (Page 74)
BRISK [6]	G	Fast non-smoothed path acceleration	m	+		*PGAs*/ Acceleration mode (BRISK, BRISKA, SOFT, SOFTA, DRIVE, DRIVEA) (Page 457)
BRISKA	P	Switch on brisk path acceleration for the programmed axes		+	-	*PGAs*/ Acceleration mode (BRISK, BRISKA, SOFT, SOFTA, DRIVE, DRIVEA) (Page 457)
BSPLINE	G	B spline	m	+		*PGAs*/ Spline interpolation (ASPLINE, BSPLINE, CSPLINE, BAUTO, BNAT, BTAN, EAUTO, ENAT, ETAN, PW, SD, PL) (Page 230)
BTAN	G	Tangential transition to first spline block	m	+		*PGAs*/ Spline interpolation (ASPLINE, BSPLINE, CSPLINE, BAUTO, BNAT, BTAN, EAUTO, ENAT, ETAN, PW, SD, PL) (Page 230)
C	A	Axis name	m/s	+		*PGAs*/ Programming the tool orientation (A..., B..., C..., LEAD, TILT) (Page 313)
C2	A	Tool orientation: RPY or Euler angle	s	+		*PGAs*/ Programming the tool orientation (A..., B..., C..., LEAD, TILT) (Page 313)
C3	A	Tool orientation: Direction/surface normal vector component	s	+		*PGAs*/ Programming the tool orientation (A..., B..., C..., LEAD, TILT) (Page 313)
C4	A	Tool orientation: Surface normal vector for beginning of block	s	+		*PGAs*/ Face milling (A4, B4, C4, A5, B5, C5) (Page 319)
C5	A	Tool orientation: Surface normal vector for end of block	s	+		*PGAs*/ Face milling (A4, B4, C4, A5, B5, C5) (Page 319)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
CAC	K	Absolute position approach		+		*PGAsl* Approaching coded positions (CAC, CIC, CDC, CACP, CACN) (Page 229)
CACN	K	Absolute approach of the value listed in the table in negative direction		+		*PGAsl* Approaching coded positions (CAC, CIC, CDC, CACP, CACN) (Page 229)
CACP	K	Absolute approach of the value listed in the table in positive direction		+		*PGAsl* Approaching coded positions (CAC, CIC, CDC, CACP, CACN) (Page 229)
CALCDAT	F	Calculates radius and center point of circle from 3 or 4 points		+	-	*PGAsl* Calculate circle data (CALCDAT) (Page 638)
CALCPOSI	F	Checking for protection zone violation, working area limitation and software limits		+	-	*PGAsl*
CALL	K	Indirect subprogram call		+		*PGAsl* Indirect subprogram call (CALL) (Page 193)
CALLPATH	P	Programmable search path for subprogram calls		+	-	*PGAsl* Extend search path for subprogram calls (CALLPATH) (Page 197)
CANCEL	P	Cancel modal synchronized action		+	-	*FBSY*
CASE	K	Conditional program branch		+		*PGAsl* Program branch (CASE ... OF ... DEFAULT ...) (Page 100)
CDC	K	Direct approach of a position		+		*PGAsl* Approaching coded positions (CAC, CIC, CDC, CACP, CACN) (Page 229)
CDOF [6]	G	Collision detection OFF	m	+		*PGsl*
CDOF2	G	Collision detection OFF, for 3D circumferential milling	m	+		*PGsl*
CDON	G	Collision detection ON	m	+		*PGsl*
CFC [6]	G	Constant feedrate on contour	m	+		*PGsl*
CFIN	G	Constant feedrate for internal radius only, not for external radius	m	+		*PGsl*
CFINE	F	Assignment of fine offset to a FRAME variable		+	-	*PGAsl* Coarse and fine offsets (CFINE, CTRANS) (Page 284)
CFTCP	G	Constant feedrate in tool center point (center point path)	m	+		*PGsl*
CHAN	K	Specify validity range for data		+		*PGAsl* Definition of user variables (DEF) (Page 24)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
CHANDATA	P	Set channel number for channel data access		+	-	*PGAsl* Working memory (CHANDATA, COMPLETE, INITIAL) (Page 213)
CHAR	K	Data type: ASCII character		+		*PGAsl* Definition of user variables (DEF) (Page 24)
CHF	A	Chamfer; value = length of chamfer	s	+		*PGsl*
CHKDM	F	Uniqueness check within a magazine		+	-	*FBWsl*
CHKDNO	F	Check for unique D numbers		+	-	*PGAsl* Free assignment of D numbers: Checking D numbers (CHKDNO) (Page 424)
CHR	A	Chamfer; value = length of chamfer in direction of movement		+		*PGsl*
CIC	K	Approach position by increments		+		*PGAsl* Approaching coded positions (CAC, CIC, CDC, CACP, CACN) (Page 229)
CIP	G	Circular interpolation through intermediate point	m	+		*PGsl*
CLEARM	P	Reset one/several markers for channel coordination		+	+	*PGAsl* Program coordination (INIT, START, WAITM, WAITMC, WAITE, SETM, CLEARM) (Page 116)
CLRINT	P	Deselect interrupt		+	-	*PGAsl* Delete assignment of interrupt routine (CLRINT) (Page 126)
CMIRROR	F	Mirror on a coordinate axis		+	-	*PGAsl* Arithmetic functions (Page 69)
COARSEA	K	Motion end when "Exact stop coarse" reached	m	+		*PGAsl* Programmable end of motion criteria (FINEA, COARSEA, IPOENDA, IPOBRKA, ADISPOSA) (Page 268)
COLLPAIR	F	Check whether it belongs to a collision pair		+		PGAsl Check for collision pair (COLLPAIR) (Page 379)
COMPCAD	G	Compressor ON: Optimum surface quality for CAD programs	m	+		*PGAsl* NC block compression (COMPON, COMPCURV, COMPCAD, COMPOF) (Page 241)
COMPCURV	G	Compressor ON: Polynomials with constant curvature	m	+		*PGAsl* NC block compression (COMPON, COMPCURV, COMPCAD, COMPOF) (Page 241)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
COMPLETE		Control instruction for reading and writing data		+		PGAsl Working memory (CHANDATA, COMPLETE, INITIAL) (Page 213)
COMPOF [6]	G	Compressor OFF	m	+		*PGAsl* NC block compression (COMPON, COMPCURV, COMPCAD, COMPOF) (Page 241)
COMPON	G	Compressor ON		+		*PGAsl* NC block compression (COMPON, COMPCURV, COMPCAD, COMPOF) (Page 241)
CONTDCON	P	Tabular contour decoding ON		+	-	*PGAsl* Generate coded contour table (CONTDCON) (Page 632)
CONTPRON	P	Activate reference preprocessing		+	-	*PGAsl* Generate contour table (CONTPRON) (Page 626)
CORROF	P	All active overlaid movements are deselected.		+	-	*PGsl*
COS	F	Cosine (trigon. function)		+	+	*PGAsl* Arithmetic functions (Page 69)
COUPDEF	P	Definition ELG group/synchronous spindle group		+	-	*PGAsl* Synchronous spindle: Programming (COUPDEF, COUPDEL, COUPON, COUPONC, COUPOF, COUPOFS, COUPRES, WAITC) (Page 531)
COUPDEL	P	Delete ELG group		+	-	*PGAsl* Synchronous spindle: Programming (COUPDEF, COUPDEL, COUPON, COUPONC, COUPOF, COUPOFS, COUPRES, WAITC) (Page 531)
COUPOF	P	ELG group / synchronous spindle pair OFF		+	-	*PGAsl* Synchronous spindle: Programming (COUPDEF, COUPDEL, COUPON, COUPONC, COUPOF, COUPOFS, COUPRES, WAITC) (Page 531)
COUPOFS	P	Deactivate ELG group/synchronous spindle pair with stop of following spindle		+	-	*PGAsl* Synchronous spindle: Programming (COUPDEF, COUPDEL, COUPON, COUPONC, COUPOF, COUPOFS, COUPRES, WAITC) (Page 531)
COUPON	P	ELG group / synchronous spindle pair ON		+	-	*PGAsl* Synchronous spindle: Programming (COUPDEF, COUPDEL, COUPON, COUPONC, COUPOF, COUPOFS, COUPRES, WAITC) (Page 531)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
COUPONC	P	Transfer activation of ELG group/synchronous spindle pair with previous programming		+	-	*PGAs/* Synchronous spindle: Programming (COUPDEF, COUPDEL, COUPON, COUPONC, COUPOF, COUPOFS, COUPRES, WAITC) (Page 531)
COUPRES	P	Reset ELG group		+	-	*PGAs/* Synchronous spindle: Programming (COUPDEF, COUPDEL, COUPON, COUPONC, COUPOF, COUPOFS, COUPRES, WAITC) (Page 531)
CP [6]	G	Path motion	m	+		*PGAs/* Cartesian PTP travel (Page 362)
CPBC	K	Generic coupling: Block change criterion		+	+	*FB3s/ (M3)*
CPDEF	K	Generic coupling: Creating a coupling module		+	+	*FB3s/ (M3)*
CPDEL	K	Generic coupling: Deletion of a coupling module		+	+	*FB3s/ (M3)*
CPFMOF	K	Generic coupling: Behavior of the following axis at complete switch-off		+	+	*FB3s/ (M3)*
CPFMON	K	Generic coupling: Behavior of the following axis at switching on		+	+	*FB3s/ (M3)*
CPFMSON	K	Generic coupling: Synchronization mode		+	+	*FB3s/ (M3)*
CPFPOS	K	Generic coupling: Synchronized position of the following axis		+	+	*FB3s/ (M3)*
CPFRS	K	Generic coupling: Co-ordinate reference system		+	+	*FB3s/ (M3)*
CPLA	K	Generic coupling: Definition of a leading axis		+	-	*FB3s/ (M3)*
CPLCTID	K	Generic coupling: Number of the curve table		+	+	*FB3s/ (M3)*
CPLDEF	K	Generic coupling: Definition of a leading axis and creation of a coupling module		+	+	*FB3s/ (M3)*
CPLDEL	K	Generic coupling: Deleting a leading axis of a coupling module		+	+	*FB3s/ (M3)*
CPLDEN	K	Generic coupling: Denominator of the coupling factor		+	+	*FB3s/ (M3)*
CPLINSC	K	Generic coupling: Scaling factor of the input value of a leading axis		+	+	*FB3s/ (M3)*
CPLINTR	K	Generic coupling: Offset value of the input value of a leading axis		+	+	*FB3s/ (M3)*
CPLNUM	K	Generic coupling: Numerator of the coupling factor		+	+	*FB3s/ (M3)*

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
CPLOF	K	Generic coupling: Switching off a leading axis of a coupling module		+	+	*FB3sl (M3)*
CPLON	K	Generic coupling: Switching on a leading axis of a coupling module		+	+	*FB3sl (M3)*
CPLOUTSC	K	Generic coupling: Scaling factor for the output value of a coupling		+	+	*FB3sl (M3)*
CPLOUTTR	K	Generic coupling: Offset value for the output value of a coupling		+	+	*FB3sl (M3)*
CPLPOS	K	Generic coupling: Synchronized position of the leading axis		+	+	*FB3sl (M3)*
CPLSETVAL	K	Generic coupling: Coupling reference		+	+	*FB3sl (M3)*
CPMALARM	K	Generic coupling: Suppression of special coupling-related alarm outputs		+	+	*FB3sl (M3)*
CPMBRAKE	K	Generic coupling: Response of the following axis to certain stop signals and stop commands		+	-	*FB3sl (M3)*
CPMPRT	K	Generic coupling: Coupling response at part program start under search run via program test		+	+	*FB3sl (M3)*
CPMRESET	K	Generic coupling: Coupling response to RESET		+	+	*FB3sl (M3)*
CPMSTART	K	Generic coupling: Coupling behavior at part program start		+	+	*FB3sl (M3)*
CPMVDI	K	Generic coupling: Response of the following axis to certain NC/PLC interface signals		+	+	*FB3sl (M3)*
CPOF	K	Generic coupling: Switching off a coupling module		+	+	*FB3sl (M3)*
CPON	K	Generic coupling: Switching on a coupling module		+	+	*FB3sl (M3)*
CPRECOF [6]	G	Programmable contour accuracy OFF	m	+		*PGAsl* Programmable contour accuracy (CPRECON, CPRECOF) (Page 464)
CPRECON	G	Programmable contour accuracy ON	m	+		*PGAsl* Programmable contour accuracy (CPRECON, CPRECOF) (Page 464)
CPRES	K	Generic coupling: Activates the configured data of the synchronous spindle coupling		+	-	
CPROT	P	Channel-specific protection zone ON/OFF		+	-	*PGAsl* Activating/deactivating protection zones (CPROT, NPROT) (Page 220)
CPROTDEF	P	Definition of a channel-specific protection zone		+	-	*PGAsl* Defining the protection zones (CPROTDEF, NPROTDEF) (Page 217)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
CPSETTYPE	K	Generic coupling: Coupling type		+	+	*FB3sl (M3)*
CPSYNCOP	K	Generic coupling: Threshold value of position synchronism "Coarse"		+	+	*FB3sl (M3)*
CPSYNCOP2	K	Generic coupling: Threshold value of position synchronism "Coarse" 2		+	+	*FB3sl (M3)*
CPSYNCOV	K	Generic coupling: Threshold value of velocity synchronism "Coarse"		+	+	*FB3sl (M3)*
CPSYNFIP	K	Generic coupling: Threshold value of position synchronism "Fine"		+	+	*FB3sl (M3)*
CPSYNFIP2	K	Generic coupling: Threshold value of position synchronism "Fine" 2		+	+	*FB3sl (M3)*
CPSYNFIV	K	Generic coupling: Threshold value of velocity synchronism "Fine"		+	+	*FB3sl (M3)*
CR	A	Circle radius	s	+		*PGsl*
CROT	F	Rotation of the current coordinate system		+	-	*PGAsl* Arithmetic functions (Page 69)
CROTS	F	Programmable frame rotations with solid angles (rotation in the specified axes)	s	+	-	*PGsl*
CRPL	F	Frame rotation in any plane		+	-	*FB1sl (K2)*
CSCALE	F	Scale factor for multiple axes		+	-	*PGAsl* Arithmetic functions (Page 69)
CSPLINE	F	Cubic spline	m	+		*PGAsl* Spline interpolation (ASPLINE, BSPLINE, CSPLINE, BAUTO, BNAT, BTAN, EAUTO, ENAT, ETAN, PW, SD, PL) (Page 230)
CT	G	Circle with tangential transition	m	+		*PGsl*
CTAB	F	Define following axis position according to leading axis position from curve table		+	+	*PGAsl* Read curve table values (CTABTSV, CTABTEV, CTABTSP, CTABTEP, CTABSSV, CTABSEV, CTAB, CTABINV, CTABTMIN, CTABTMAX) (Page 512)
CTABDEF	P	Table definition ON		+	-	*PGAsl* Define curve tables (CTABDEF, CATBEND) (Page 501)
CTABDEL	P	Clear curve table		+	-	*PGAsl* Delete curve tables (CTABDEL) (Page 507)
CTABEND	P	Table definition OFF		+	-	*PGAsl* Define curve tables (CTABDEF, CATBEND) (Page 501)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
CTABEXISTS	F	Checks the curve table with number n		+	+	*PGAs/* Check for presence of curve table (CTABEXISTS) (Page 507)
CTABFNO	F	Number of curve tables still possible in the memory		+	+	*PGAs/* Curve tables: Check use of resources (CTABNO, CTABNOMEM, CTABFNO, CTABSEGID, CTABSEG, CTABFSEG, CTABMSEG, CTABPOLID, CTABPOL, CTABFPOL, CTABMPOL) (Page 517)
CTABFPOL	F	Number of polynomials still possible in the memory		+	+	*PGAs/* Curve tables: Check use of resources (CTABNO, CTABNOMEM, CTABFNO, CTABSEGID, CTABSEG, CTABFSEG, CTABMSEG, CTABPOLID, CTABPOL, CTABFPOL, CTABMPOL) (Page 517)
CTABFSEG	F	Number of curve segments still possible in the memory		+	+	*PGAs/* Curve tables: Check use of resources (CTABNO, CTABNOMEM, CTABFNO, CTABSEGID, CTABSEG, CTABFSEG, CTABMSEG, CTABPOLID, CTABPOL, CTABFPOL, CTABMPOL) (Page 517)
CTABID	F	Returns table number of the nth curve table		+	+	*PGAs/* Curve tables: Determine table properties (CTABID, CTABISLOCK, CTABMEMTYP, CTABPERIOD) (Page 510)
CTABINV	F	Define leading axis position according to following axis position from curve table		+	+	*PGAs/* Read curve table values (CTABTSV, CTABTEV, CTABTSP, CTABTEP, CTABSSV, CTABSEV, CTAB, CTABINV, CTABTMIN, CTABTMAX) (Page 512)
CTABISLOCK	F	Returns the lock state of the curve table with number n		+	+	*PGAs/* Curve tables: Determine table properties (CTABID, CTABISLOCK, CTABMEMTYP, CTABPERIOD) (Page 510)
CTABLOCK	P	Delete and overwrite, lock		+	+	*PGAs/* Locking curve tables to prevent deletion and overwriting (CTABLOCK, CTABUNLOCK) (Page 509)
CTABMEMTYP	F	Returns the memory in which curve table number n is created.		+	+	*PGAs/* Curve tables: Determine table properties (CTABID, CTABISLOCK, CTABMEMTYP, CTABPERIOD) (Page 510)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
CTABMPOL	F	Max. number of polynomials still possible in the memory		+	+	*PGAs/* Curve tables: Check use of resources (CTABNO, CTABNOMEM, CTABFNO, CTABSEGID, CTABSEG, CTABFSEG, CTABMSEG, CTABPOLID, CTABPOL, CTABFPOL, CTABMPOL) (Page 517)
CTABMSEG	F	Max. number of curve segments still possible in the memory		+	+	*PGAs/* Curve tables: Check use of resources (CTABNO, CTABNOMEM, CTABFNO, CTABSEGID, CTABSEG, CTABFSEG, CTABMSEG, CTABPOLID, CTABPOL, CTABFPOL, CTABMPOL) (Page 517)
CTABNO	F	Number of defined curve tables in SRAM or DRAM		+	+	*FB3s/ (M3)*
CTABNOMEM	F	Number of defined curve tables in SRAM or DRAM		+	+	*PGAs/* Curve tables: Check use of resources (CTABNO, CTABNOMEM, CTABFNO, CTABSEGID, CTABSEG, CTABFSEG, CTABMSEG, CTABPOLID, CTABPOL, CTABFPOL, CTABMPOL) (Page 517)
CTABPERIOD	F	Returns the table periodicity of curve table number n		+	+	*PGAs/* Curve tables: Determine table properties (CTABID, CTABISLOCK, CTABMEMTYP, CTABPERIOD) (Page 510)
CTABPOL	F	Number of polynomials already used in the memory		+	+	*PGAs/* Curve tables: Check use of resources (CTABNO, CTABNOMEM, CTABFNO, CTABSEGID, CTABSEG, CTABFSEG, CTABMSEG, CTABPOLID, CTABPOL, CTABFPOL, CTABMPOL) (Page 517)
CTABPOLID	F	Number of the curve polynomials used by the curve table with number n		+	+	*PGAs/* Curve tables: Check use of resources (CTABNO, CTABNOMEM, CTABFNO, CTABSEGID, CTABSEG, CTABFSEG, CTABMSEG, CTABPOLID, CTABPOL, CTABFPOL, CTABMPOL) (Page 517)
CTABSEG	F	Number of curve segments already used in the memory		+	+	*PGAs/* Curve tables: Check use of resources (CTABNO, CTABNOMEM, CTABFNO, CTABSEGID, CTABSEG, CTABFSEG, CTABMSEG, CTABPOLID, CTABPOL, CTABFPOL, CTABMPOL) (Page 517)
CTABSEGID	F	Number of the curve segments used by the curve table with number n		+	+	*PGAs/* Curve tables: Check use of resources (CTABNO, CTABNOMEM, CTABFNO, CTABSEGID, CTABSEG, CTABFSEG, CTABMSEG, CTABPOLID, CTABPOL, CTABFPOL, CTABMPOL) (Page 517)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
CTABSEV	F	Returns the final value of the following axis of a segment of the curve table		+	+	*PGAsl* Read curve table values (CTABTSV, CTABTEV, CTABTSP, CTABTEP, CTABSSV, CTABSEV, CTAB, CTABINV, CTABTMIN, CTABTMAX) (Page 512)
CTABSSV	F	Returns the initial value of the following axis of a segment of the curve table		+	+	*PGAsl* Read curve table values (CTABTSV, CTABTEV, CTABTSP, CTABTEP, CTABSSV, CTABSEV, CTAB, CTABINV, CTABTMIN, CTABTMAX) (Page 512)
CTABTEP	F	Returns the value of the leading axis at curve table end		+	+	*PGAsl* Read curve table values (CTABTSV, CTABTEV, CTABTSP, CTABTEP, CTABSSV, CTABSEV, CTAB, CTABINV, CTABTMIN, CTABTMAX) (Page 512)
CTABTEV	F	Returns the value of the the following axis at curve table end		+	+	*PGAsl* Read curve table values (CTABTSV, CTABTEV, CTABTSP, CTABTEP, CTABSSV, CTABSEV, CTAB, CTABINV, CTABTMIN, CTABTMAX) (Page 512)
CTABTMAX	F	Returns the maximum value of the following axis of the curve table		+	+	*PGAsl* Read curve table values (CTABTSV, CTABTEV, CTABTSP, CTABTEP, CTABSSV, CTABSEV, CTAB, CTABINV, CTABTMIN, CTABTMAX) (Page 512)
CTABTMIN	F	Returns the minimum value of the following axis of the curve table		+	+	*PGAsl* Read curve table values (CTABTSV, CTABTEV, CTABTSP, CTABTEP, CTABSSV, CTABSEV, CTAB, CTABINV, CTABTMIN, CTABTMAX) (Page 512)
CTABTSP	F	Returns the value of the leading axis at curve table start		+	+	*PGAsl* Read curve table values (CTABTSV, CTABTEV, CTABTSP, CTABTEP, CTABSSV, CTABSEV, CTAB, CTABINV, CTABTMIN, CTABTMAX) (Page 512)
CTABTSV	F	Returns the value of the following axis at curve table start		+	+	*PGAsl* Read curve table values (CTABTSV, CTABTEV, CTABTSP, CTABTEP, CTABSSV, CTABSEV, CTAB, CTABINV, CTABTMIN, CTABTMAX) (Page 512)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
CTABUNLOCK	P	Revoke delete and overwrite lock		+	+	*PGAs/* Locking curve tables to prevent deletion and overwriting (CTABLOCK, CTABUNLOCK) (Page 509)
CTOL	K	Contour tolerance for compressor functions, orientation smoothing and smoothing types		+		*PGAs/* Programmable contour/orientation tolerance (CTOL, OTOL, ATOL) (Page 488)
CTRANS	F	Zero offset for multiple axes		+	-	*PGAs/* Coarse and fine offsets (CFINE, CTRANS) (Page 284)
CUT2D [6]	G	2D tool offset	m	+		*PGs/*
CUT2DF	G	2D tool offset The tool offset is applied relative to the current frame (inclined plane).	m	+		*PGs/*
CUT3DC	G	3D tool offset circumferential milling	m	+		*PGAs/* Activate 3D tool offsets (CUT3DC..., CUT3DF...) (Page 404)
CUT3DCC	G	3D tool offset circumferential milling with limitation surfaces	m	+		*PGAs/* 3D tool offset Taking into consideration a limitation surface (CUT3DCC, CUT3DCCD) (Page 414)
CUT3DCCD	G	3D tool offset circumferential milling with limitation surfaces with differential tool	m	+		*PGAs/* 3D tool offset Taking into consideration a limitation surface (CUT3DCC, CUT3DCCD) (Page 414)
CUT3DF	G	3D tool offset face milling	m	+		*PGAs/* Activate 3D tool offsets (CUT3DC..., CUT3DF...) (Page 404)
CUT3DFF	G	3D tool offset face milling with constant tool orientation dependent on active frame	m	+		*PGAs/* Activate 3D tool offsets (CUT3DC..., CUT3DF...) (Page 404)
CUT3DFS	G	3D tool offset face milling with constant tool orientation independent of active frame	m	+		*PGAs/* Activate 3D tool offsets (CUT3DC..., CUT3DF...) (Page 404)
CUTCONOF [6]	G	Constant radius compensation OFF	m	+		*PGs/*
CUTCONON	G	Constant radius compensation ON	m	+		*PGs/*
CUTMOD	K	Activate "Modification of the offset data for rotatable tools"		+		*PGAs/* Cutting data modification for tools that can be rotated (CUTMOD) (Page 439)
CYCLE60	C	Engraving cycle		+		*PGAs/* Engraving cycle - CYCLE60 (Page 683)
CYCLE61	C	Face milling		+		*PGAs/* Face milling - CYCLE61 (Page 661)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
CYCLE62	C	Contour call		+		*PGAs* Contour call - CYCLE62 (Page 685)
CYCLE63	C	Contour pocket milling		+		*PGAs* Milling a contour pocket - CYCLE63 (Page 689)
CYCLE64	C	Contour pocket predrilling		+		*PGAs* Predrilling a contour pocket - CYCLE64 (Page 688)
CYCLE70	C	Thread milling		+		*PGAs* Thread milling - CYCLE70 (Page 681)
CYCLE72	C	Path milling		+		*PGAs* Path milling - CYCLE72 (Page 685)
CYCLE76	C	Milling the rectangular spigot		+		*PGAs* Rectangular spigot milling - CYCLE76 (Page 667)
CYCLE77	C	Circular spigot milling		+		*PGAs* Circular spigot milling - CYCLE77 (Page 669)
CYCLE78	C	Drill and thread milling		+		*PGAs* Thread milling - CYCLE78 (Page 654)
CYCLE79	C	Multiple edge		+		*PGAs* Multiple-edge - CYCLE79 (Page 671)
CYCLE81	C	Drilling, centering		+		*PGAs* Drilling, centering - CYCLE81 (Page 642)
CYCLE82	C	Drilling, counterboring		+		*PGAs*
CYCLE83	C	Deep-hole drilling		+		*PGAs* Deep-hole drilling - CYCLE83 (Page 645)
CYCLE84	C	Tapping without compensating chuck		+		*PGAs* Tapping without compensating chuck - CYCLE84 (Page 649)
CYCLE85	C	Reaming		+		*PGAs* Reaming - CYCLE85 (Page 644)
CYCLE86	C	Boring		+		*PGAs* Boring - CYCLE86 (Page 648)
CYCLE92	C	Parting		+		*PGAs* Cut-off - CYCLE92 (Page 705)
CYCLE95	C	Stock removal along the contour		+		*PGAs* Contour cutting - CYCLE95 (Page 706)
CYCLE98	C	Thread chain		+		*PGAs* Thread chain - CYCLE98 (Page 702)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
CYCLE99	C	Thread cutting		+		*PGAs*/ Thread turning - CYCLE99 (Page 699)
CYCLE800	C	Swiveling		+		*PGAs*/ Swiveling - CYCLE800 (Page 712)
CYCLE801	C	Grid or frame		+		*PGAs*/ Grid or frame - CYCLE801 (Page 658)
CYCLE802	C	Arbitrary positions		+		*PGAs*/
CYCLE832	C	High Speed Settings		+		*PGAs*/ High Speed Settings - CYCLE832 (Page 714)
CYCLE840	C	Tapping with compensating chuck		+		*PGAs*/ Tapping with compensating chuck - CYCLE840 (Page 652)
CYCLE899	C	Open slot milling		+		*PGAs*/ Mill open slot - CYCLE899 (Page 677)
CYCLE930	C	Groove		+		*PGAs*/ Groove - CYCLE930 (Page 694)
CYCLE940	C	Undercut forms		+		*PGAs*/ Undercut forms - CYCLE940 (Page 696)
CYCLE951	C	Stock removal		+		*PGAs*/ Stock removal - CYCLE951 (Page 692)
CYCLE952	C	Contour grooving		+		*PGAs*/ Contour grooving - CYCLE952 (Page 708)
D	A	Tool offset number		+		*PGs*/
D0	A	With D0, offsets for the tool are ineffective		+		*PGs*/
DAC	K	Absolute non-modal axis-specific diameter programming	s	+		*PGs*/
DC	K	Absolute dimensions for rotary axes, approach position directly	s	+		*PGs*/
DEF	K	Variable definition		+		*PGAs*/ Definition of user variables (DEF) (Page 24)
DEFAULT	K	Branch in CASE branch		+		*PGAs*/ Program branch (CASE ... OF ... DEFAULT ...) (Page 100)
DEFINE	K	Keyword for macro definitions		+		*PGAs*/ Macro technique (DEFINE ... AS) (Page 205)
DELAYFSTOF	P	Define the end of a stop delay section	m	+	-	*PGAs*/ Program sections that can be conditionally interrupted (DELAYFSTON, DELAYFSTOF) (Page 469)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
DELAYFSTON	P	Define the start of a stop delay section	m	+	-	*PGAsl* Program branch (CASE ... OF ... DEFAULT ...) (Page 100)
DELDL	F	Delete additive offsets		+	-	*PGAsl* Delete additive offsets (DELDL) (Page 390)
DELDTG	P	Delete distance-to-go		-	+	*FBSY*
DELETE	P	Delete the specified file. The file name can be specified with path and file identifier.		+	-	*PGAsl* Delete file (DELETE) (Page 144)
DELMLOWNER	F	Delete owner magazine location of the tool		+	-	*FBWsl*
DELMLRES	F	Delete magazine location reservation		+	-	*FBWsl*
DELMT	P	Delete multitool		+	-	*FBWsl*
DELOBJ	F	Deletion of elements from kinematic chains, protection zones, protection zone elements, collision pairs and transformation data		+		*PGAsl* Deletion of components (DELOBJ) (Page 375)
DELT	P	Delete Tool		+	-	*FBWsl*
DELTC	P	Delete toolholder data record		+	-	*FBWsl*
DELTOOLENV	F	Delete data records describing tool environments		+	-	*FB1sl (W1)*
DIACYCOFA	K	Axis-specific modal diameter programming: OFF in cycles	m	+		*FB1sl (P1)*
DIAM90	G	Diameter programming for G90, radius programming for G91	m	+		*PGAsl*
DIAM90A	K	Axis-specific modal diameter programming for G90 and AC, radius programming for G91 and IC	m	+		*PGsl*
DIAMCHAN	K	Transfer of all axes from MD axis functions to diameter programming channel status		+		*PGsl*
DIAMCHANA	K	Transfer of the diameter programming channel status		+		*PGsl*
DIAMCYCOF	G	Channel-specific diameter programming: OFF in cycles	m	+		*FB1sl (P1)*
DIAMOF [6]	G	Diameter programming: OFF Normal position, see machine manufacturer	m	+		*PGsl*
DIAMOFA	K	Axis-specific modal diameter programming: OFF Normal position, see machine manufacturer	m	+		*PGsl*
DIAMON	G	Diameter programming: ON	m	+		*PGsl*

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
DIAMONA	K	Axis-specific modal diameter programming: ON Activation, see machine manufacturer	m	+		*PGs/*
DIC	K	Relative non-modal axis-specific diameter programming	s	+		*PGs/*
DILF	A	Retraction path (length)	m	+		*PGs/*
DISABLE	P	Interrupt OFF		+	-	*PGAs/* Deactivating/reactivating the assignment of an interrupt routine (DISABLE, ENABLE) (Page 125)
DISC	A	Transition circle overshoot tool radius compensation	m	+		*PGs/*
DISCL	A	Clearance between the end point of the fast infeed motion and the machining plane		+		*PGs/*
DISPLOF	PA	Suppress current block display		+		*PGAs/* Suppress current block display (DISPLOF, DISPLON, ACTBLOCNO) (Page 172)
DISPLON	PA	Revoke suppression of the current block display		+		*PGAs/* Suppress current block display (DISPLOF, DISPLON, ACTBLOCNO) (Page 172)
DISPR	A	Path differential for repositioning	s	+		*PGAs/* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)
DISR	A	Distance for repositioning	s	+		*PGAs/* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)
DISRP	A	Distance between the retraction plane and the machining plane during smooth approach and retraction		+		*PGs/*
DITE	A	Thread run-out path	m	+		*PGs/*
DITS	A	Thread run-in path	m	+		*PGs/*
DIV	K	Integer division		+		*PGAs/* Arithmetic functions (Page 69)
DL	A	Select location-dependent additive tool offset (DL, total set-up offset)	m	+		*PGAs/* Selecting additive offsets (DL) (Page 388)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
DO	A	Keyword for synchronized action, triggers action when condition is fulfilled		-	+	*FBSY*
DRFOF	P	Deactivation of handwheel offsets (DRF)	m	+	-	*PGsl*
DRIVE	G	Velocity-dependent path acceleration	m	+		*PGAsl* Acceleration mode (BRISK, BRISKA, SOFT, SOFTA, DRIVE, DRIVEA) (Page 457)
DRIVEA	P	Activate bent acceleration characteristic curve for the programmed axes		+	-	*PGAsl* Acceleration mode (BRISK, BRISKA, SOFT, SOFTA, DRIVE, DRIVEA) (Page 457)
DYNFINISH	G	Dynamic response for smooth finishing	m	+		*PGAsl* Activation of technology-specific dynamic values (DYNNORM, DYNPOS, DYNROUGH, DYNSEMIFIN, DYNFINISH) (Page 461)
DYNNORM [6]	G	Standard dynamic response	m	+		*PGAsl* Activation of technology-specific dynamic values (DYNNORM, DYNPOS, DYNROUGH, DYNSEMIFIN, DYNFINISH) (Page 461)
DYNPOS	G	Dynamic response for positioning mode, tapping	m	+		*PGAsl* Activation of technology-specific dynamic values (DYNNORM, DYNPOS, DYNROUGH, DYNSEMIFIN, DYNFINISH) (Page 461)
DYNROUGH	G	Dynamic response for roughing	m	+		*PGAsl* Activation of technology-specific dynamic values (DYNNORM, DYNPOS, DYNROUGH, DYNSEMIFIN, DYNFINISH) (Page 461)
DYNSEMIFIN	G	Dynamic response for finishing	m	+		*PGAsl* Activation of technology-specific dynamic values (DYNNORM, DYNPOS, DYNROUGH, DYNSEMIFIN, DYNFINISH) (Page 461)
DZERO	P	Marks all D numbers of the TO unit as invalid		+	-	*PGAsl* Free assignment of D numbers: Invalidate D numbers (DZERO) (Page 427)
EAUTO	G	Definition of the last spline section by means of the last 3 points	m	+		*PGAsl* Spline interpolation (ASPLINE, BSPLINE, CSPLINE, BAUTO, BNAT, BTAN, EAUTO, ENAT, ETAN, PW, SD, PL) (Page 230)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
EGDEF	P	Definition of an electronic gear		+	-	*PGAsl* Defining an electronic gear (EGDEF) (Page 524)
EGDEL	P	Delete coupling definition for the following axis		+	-	*PGAsl* Deleting the definition of an electronic gear (EGDEL) (Page 530)
EGOFC	P	Turn off electronic gear continuously		+	-	*PGAsl* Switching-in the electronic gearbox (EGOFS, EGOFC) (Page 529)
EGOFS	P	Turn off electronic gear selectively		+	-	*PGAsl* Switching-in the electronic gearbox (EGOFS, EGOFC) (Page 529)
EGON	P	Turn on electronic gear		+	-	*PGAsl* Switching-in the electronic gearbox (EGOFS, EGOFC) (Page 529)
EGONSYN	P	Turn on electronic gear		+	-	*PGAsl* Switching-in the electronic gearbox (EGOFS, EGOFC) (Page 529)
EGONSYNE	P	Turn on electronic gear, with specification of approach mode		+	-	*PGAsl* Switching-in the electronic gearbox (EGOFS, EGOFC) (Page 529)
ELSE	K	Program branch, if IF condition not fulfilled		+		*PGAsl* Conditional statement and branch (IF, ELSE, ENDIF) (Page 110)
ENABLE	P	Interrupt ON		+	-	*PGAsl* Deactivating/reactivating the assignment of an interrupt routine (DISABLE, ENABLE) (Page 125)
ENAT [6]	G	Natural transition to next traversing block	m	+		*PGAsl* Spline interpolation (ASPLINE, BSPLINE, CSPLINE, BAUTO, BNAT, BTAN, EAUTO, ENAT, ETAN, PW, SD, PL) (Page 230)
ENDFOR	K	End line of FOR counter loop		+		*PGAsl* Count loop (FOR ... TO ..., ENDFOR) (Page 112)
ENDIF	K	End line of IF branch		+		*PGAsl* Conditional statement and branch (IF, ELSE, ENDIF) (Page 110)
ENDLABEL	K	End label for part program repetitions with REPEAT		+		*PGAsl, FB1sl (K1)* Repeat program section (REPEAT, REPEATB, ENDLABEL, P) (Page 102)
ENDLOOP	K	End line of endless program loop LOOP		+		*PGAsl* Continuous program loop (LOOP, ENDLOOP) (Page 111)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
ENDPROC	K	End line of program with start line PROC		+		
ENDWHILE	K	End line of WHILE loop		+		*PGAsl* Program loop with condition at start of loop (WHILE, ENDWHILE) (Page 114)
ESRR	P	Parameterizing drive-autonomous ESR retraction in the drive		+		*PGAsl* Configuring drive-integrated retraction (ESRS) (Page 623)
ESRS	P	Parameterizing drive-autonomous ESR shutdown in the drive		+		*PGAsl* Configuring drive-integrated stopping (ESRS) (Page 622)
ETAN	G	Tangential transition to next traversing block at spline begin	m	+		*PGAsl* Spline interpolation (ASPLINE, BSPLINE, CSPLINE, BAUTO, BNAT, BTAN, EAUTO, ENAT, ETAN, PW, SD, PL) (Page 230)
EVERY	K	Execute synchronized action on transition of condition from FALSE to TRUE		-	+	*FBSY*
EX	K	Keyword for value assignment in exponential notation		+		*PGAsl* Predefined user variables: Arithmetic parameters (R) (Page 20)
EXECSTRING	P	Transfer of a string variable with the executing part program line		+	-	*PGAsl* Indirectly programming part program lines (EXECSTRING) (Page 68)
EXECTAB	P	Execute an element from a motion table		+	-	*PGAsl* Indirectly programming part program lines (EXECSTRING) (Page 68)
EXECUTE	P	Program execution ON		+	-	*PGAsl* Deactivate contour preparation (EXECUTE) (Page 640)
EXP	F	Exponential function ex		+	+	*PGAsl* Arithmetic functions (Page 69)
EXTCALL	A	Execute external subprogram		+	+	*PGAsl* Execute external subprogram (840D sl) (EXTCALL) (Page 198)
EXTCLOSE	P	Closing external device / file that was opened for writing		+	-	*PGAsl* Process DataShare - output to an external device/file (EXTOPEN, WRITE, EXTCLOSE) (Page 605)
EXTERN	K	Declaration of a subprogram with parameter transfer		+		*PGAsl* Subprogram call without parameter transfer (Page 184)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
EXTOPEN	P	Opening external device / file for the channel for writing		+	-	*PGAs/* Process DataShare - output to an external device/file (EXTOPEN, WRITE, EXTCLOSE) (Page 605)
F	A	Feedrate value (in conjunction with G4 the dwell time is also programmed with F)		+	+	*PGs/*
FA	K	Axial feedrate	m	+	+	*PGs/*
FAD	A	Infeed rate for soft approach and retraction		+		*PGs/*
FALSE	K	Logical constant: Incorrect		+		*PGAs/* Definition of user variables (DEF) (Page 24)
FB	A	Non-modal feedrate		+		*PGs/*
FCTDEF	P	Define polynomial function		+	-	*PGAs/* Online tool offset (PUTFTOCF, FCTDEF, PUTFTOC, FTOCON, FTOCOF) (Page 399)
FCUB	G	Feedrate variable according to cubic spline	m	+		*PGAs/* Feedrate characteristic (FNORM, FLIN, FCUB, FPO) (Page 452)
FD	A	Path feedrate for handwheel override	s	+		*PGs/*
FDA	K	Axis feedrate for handwheel override	s	+		*PGs/*
FENDNORM [6]	G	Corner deceleration OFF	m	+		*PGAs/* Feedrate reduction with corner deceleration (FENDNORM, G62, G621) (Page 267)
FFWOF [6]	G	Feedforward control OFF	m	+		*PGAs/* Traversing with feedforward control (FFWON, FFWOF) (Page 463)
FFWON	G	Feedforward control ON	m	+		*PGAs/* Traversing with feedforward control (FFWON, FFWOF) (Page 463)
FGREF	K	Reference radius for rotary axes or path reference factors for orientation axes (vector interpolation)	m	+		*PGs/*
FGROUP	P	Definition of axis/axes with path feedrate		+	-	*PGs/*
FI	K	Parameter for access to frame data: Fine offset		+		*PGAs/* Reading and changing frame components (TR, FI, RT, SC, MI) (Page 280)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
FIFOCTRL	G	Control of preprocessing buffer	m	+		*PGAsl* Program sequence with preprocessing memory (STOPFIFO, STARTFIFO, FIFOCTRL, STOPRE) (Page 466)
FILEDATE	P	Returns date of most recent write access to file		+	-	*PGAsl* Read out file information (FILEDATE, FILETIME, FILESIZE, FILESTAT, FILEINFO) (Page 150)
FILEINFO	P	Returns summary information listing FILEDATE, FILESIZE, FILESTAT, and FILETIME		+	-	*PGAsl* Read out file information (FILEDATE, FILETIME, FILESIZE, FILESTAT, FILEINFO) (Page 150)
FILESIZE	P	Returns current file size		+	-	*PGAsl* Read out file information (FILEDATE, FILETIME, FILESIZE, FILESTAT, FILEINFO) (Page 150)
FILESTAT	P	Returns file status of rights for read, write, execute, display, delete (rwxsd)		+	-	*PGAsl* Read out file information (FILEDATE, FILETIME, FILESIZE, FILESTAT, FILEINFO) (Page 150)
FILETIME	P	Returns time of most recent write access to file		+	-	*PGAsl* Read out file information (FILEDATE, FILETIME, FILESIZE, FILESTAT, FILEINFO) (Page 150)
FINEA	K	End of motion when "Exact stop fine" reached	m	+		*PGAsl* Programmable end of motion criteria (FINEA, COARSEA, IPOENDA, IPOBRKA, ADISPOSA) (Page 268)
FL	K	Limit velocity for synchronized axis	m	+		*PGsl*
FLIN	G	Feed linear variable	m	+		*PGAsl* Feedrate characteristic (FNORM, FLIN, FCUB, FPO) (Page 452)
FMA	K	Multiple feedrates axial	m	+		*PGsl*
FNORM [6]	G	Feedrate normal to DIN 66025	m	+		*PGAsl* Feedrate characteristic (FNORM, FLIN, FCUB, FPO) (Page 452)
FOC	K	Non-modal torque/force limitation	s	-	+	*FBSY*
FOCOF	K	Switch off modal torque/force limitation	m	-	+	*FBSY*
FOCON	K	Switch on modal torque/force limitation	m	-	+	*FBSY*
FOR	K	Counter loop with fixed number of passes		+		*PGAsl* Count loop (FOR ... TO ..., ENDFOR) (Page 112)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
FP	A	Fixed point: Number of fixed point to be approached	s	+		*PGsl*
FPO	K	Feedrate characteristic programmed via a polynomial		+		*PGAsl* Feedrate characteristic (FNORM, FLIN, FCUB, FPO) (Page 452)
FPR	P	Rotary axis identifier		+	-	*PGsl*
FPRAOF	P	Deactivate revolutional feedrate		+	-	*PGsl*
FPRAON	P	Activate revolutional feedrate		+	-	*PGsl*
FRAME	K	Data type for the definition of coordinate systems		+		*PGAsl* Defining new frames (DEF FRAME) (Page 283)
FRC	A	Feedrate for radius and chamfer	s	+		*PGsl*
FRCM	A	Feedrate for radius and chamfer, modal	m	+		*PGsl*
FROM	K	The action is executed if the condition is fulfilled once and as long as the synchronized action is active		-	+	*FBSY*
FTOC	P	Change fine tool offset		-	+	*FBSY*
FTOCOF [6]	G	Online fine tool offset OFF	m	+		*PGAsl* Online tool offset (PUTFTOCF, FCTDEF, PUTFTOC, FTOCON, FTOCOF) (Page 399)
FTOCON	G	Online fine tool offset ON	m	+		*PGAsl* Online tool offset (PUTFTOCF, FCTDEF, PUTFTOC, FTOCON, FTOCOF) (Page 399)
FXS	K	Travel to fixed stop ON	m	+	+	*PGsl*
FXST	K	Torque limit for travel to fixed stop	m	+	+	*PGsl*
FXSW	K	Monitoring window for travel to fixed stop		+	+	*PGsl*
FZ	K	Tooth feedrate	m	+		*PGsl*
G0	G	Linear interpolation with rapid traverse (rapid traverse motion)	m	+		*PGsl*
G1 [6]	G	Linear interpolation with feedrate (linear interpolation)	m	+		*PGsl*
G2	G	Circular interpolation clockwise	m	+		*PGsl*
G3	G	Circular interpolation counter-clockwise	m	+		*PGsl*
G4	G	Dwell time, preset	s	+		*PGsl*
G5	G	Oblique plunge-cut grinding	s	+		*PGAsl* Inclined axis (TRAANG) (Page 357)
G7	G	Compensatory motion during oblique plunge-cut grinding	s	+		*PGAsl* Inclined axis (TRAANG) (Page 357)
G9	G	Exact stop - deceleration	s	+		*PGsl*

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
G17 [6]	G	Selection of working plane X/Y	m	+		*PGsl*
G18	G	Selection of working plane Z/X	m	+		*PGsl*
G19	G	Selection of working plane Y/Z	m	+		*PGsl*
G25	G	Lower working area limitation	s	+		*PGsl*
G26	G	Upper working area limitation	s	+		*PGsl*
G33	G	Thread cutting with constant lead	m	+		*PGsl*
G34	G	Thread cutting with linear increasing lead	m	+		*PGsl*
G35	G	Thread cutting with linear decreasing lead	m	+		*PGsl*
G40 [6]	G	Tool radius compensation OFF	m	+		*PGsl*
G41	G	Tool radius compensation left of contour	m	+		*PGsl*
G42	G	Tool radius compensation right of contour	m	+		*PGsl*
G53	G	Suppression of current zero offset (non-modal)	s	+		*PGsl*
G54	G	1st settable zero offset	m	+		*PGsl*
G55	G	2nd settable zero offset	m	+		*PGsl*
G56	G	3rd settable zero offset	m	+		*PGsl*
G57	G	4th settable zero offset	m	+		*PGsl*
G58 (840D sl)	G	Axial programmable zero offset, absolute, coarse offset	s	+		*PGsl*
G58 (828D)	G	5th settable zero offset	m	+		*PGsl*
G59 (840D sl)	G	Axial programmable zero offset, additive, fine offset	s	+		*PGsl*
G59 (828D)	G	6th settable zero offset	m	+		*PGsl*
G60 [6]	G	Exact stop - deceleration	m	+		*PGsl*
G62	G	Corner deceleration at inside corners when tool radius offset is active (G41, G42)	m	+		*PGAsl* Feedrate reduction with corner deceleration (FENDNORM, G62, G621) (Page 267)
G63	G	Tapping with compensating chuck	s	+		*PGsl*
G64	G	Continuous-path mode	m	+		*PGsl*
G70	G	Inch dimensions for geometric specifications (lengths)	m	+	+	*PGsl*
G71 [6]	G	Metric dimensions for geometric specifications (lengths)	m	+	+	*PGsl*
G74	G	Approaching a reference point	s	+		*PGsl*
G75	G	Approaching a fixed point	s	+		*PGsl*
G90 [6]	G	Absolute dimensions	m/s	+		*PGsl*
G91	G	Incremental dimensions	m/s	+		*PGsl*
G93	G	Inverse-time feedrate rpm	m	+		*PGsl*

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
G94 [6]	G	Linear feedrate F in mm/min or inch/min and degree/min	m	+		*PGsl*
G95	G	Revolutional feedrate F in mm/rev or inch/rev	m	+		*PGsl*
G96	G	Constant cutting rate (as for G95) ON	m	+		*PGsl*
G97	G	Constant cutting rate (as for G95) OFF	m	+		*PGsl*
G110	G	Pole programming relative to the last programmed setpoint position	s	+		*PGsl*
G111	G	Pole programming relative to zero of current workpiece coordinate system	s	+		*PGsl*
G112	G	Pole programming relative to the last valid pole	s	+		*PGsl*
G140 [6]	G	SAR approach direction defined by G41/G42	m	+		*PGsl*
G141	G	SAR approach direction to left of contour	m	+		*PGsl*
G142	G	SAR approach direction to right of contour	m	+		*PGsl*
G143	G	SAR approach direction tangent-dependent	m	+		*PGsl*
G147	G	Soft approach with straight line	s	+		*PGsl*
G148	G	Soft retraction with straight line	s	+		*PGsl*
G153	G	Suppression of current frames including basic frame	s	+		*PGsl*
G247	G	Soft approach with quadrant	s	+		*PGsl*
G248	G	Soft retraction with quadrant	s	+		*PGsl*
G290 [6]	G	Switch over to SINUMERIK mode ON	m	+		*FBWsl*
G291	G	Switch over to ISO2/3 mode ON	m	+		*FBWsl*
G331	G	Rigid tapping, positive lead, clockwise	m	+		*PGsl*
G332	G	Rigid tapping, negative lead, counter-clockwise	m	+		*PGsl*
G340 [6]	G	Spatial approach block (depth and in plane at the same time (helix))	m	+		*PGsl*
G341	G	Initial infeed on perpendicular axis (z), then approach in plane	m	+		*PGsl*
G347	G	Soft approach with semicircle	s	+		*PGsl*
G348	G	Soft retraction with semicircle	s	+		*PGsl*
G450 [6]	G	Transition circle	m	+		*PGsl*
G451	G	Intersection of equidistances	m	+		*PGsl*

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
G460 [6]	G	Activation of collision detection for the approach and retraction block	m	+		*PGs/*
G461	G	Insertion of a circle into the TRC block	m	+		*PGs/*
G462	G	Insertion of a straight line into the TRC block	m	+		*PGs/*
G500 [6]	G	Deactivation of all adjustable frames, basic frames are active	m	+		*PGs/*
G505 ... G599	G	5 ... 99. settable zero offset	m	+		*PGs/*
G601 [6]	G	Block change at exact stop fine	m	+		*PGs/*
G602	G	Block change at exact stop coarse	m	+		*PGs/*
G603	G	Block change at IPO block end	m	+		*PGs/*
G621	G	Corner deceleration at all corners	m	+		*PGAs/* Feedrate reduction with corner deceleration (FENDNORM, G62, G621) (Page 267)
G641	G	Continuous-path mode with smoothing as per distance criterion (= programmable rounding clearance)	m	+		*PGs/*
G642	G	Continuous-path mode with smoothing within the defined tolerances	m	+		*PGs/*
G643	G	Continuous-path mode with smoothing within the defined tolerances (block-internal)	m	+		*PGs/*
G644	G	Continuous-path mode with smoothing with maximum possible dynamic response	m	+		*PGs/*
G645	G	Continuous-path mode with smoothing and tangential block transitions within the defined tolerances	m	+		*PGs/*
G700	G	Inch dimensions for geometric and technological specifications (lengths, feedrate)	m	+	+	*PGs/*
G710 [6]	G	Metric dimensions for geometric and technological specifications (lengths, feedrate)	m	+	+	*PGs/*
G810 [6], ..., G819	G	G group reserved for the OEM user		+		*PGAs/* Special functions for OEM users (OMA1 ... OMA5, OEMIPO1, OEMIPO2, G810 ... G829) (Page 266)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
G820 [6], ..., G829	G	G group reserved for the OEM user		+		*PGAs/* Special functions for OEM users (OMA1 ... OMA5, OEMIPO1, OEMIPO2, G810 ... G829) (Page 266)
G931	G	Feedrate specified by traversing time	m	+		
G942	G	Freeze linear feedrate and constant cutting rate or spindle speed	m	+		
G952	G	Freeze revolutional feedrate and constant cutting rate or spindle speed	m	+		
G961	G	Constant cutting rate and linear feedrate	m	+		*PGs/*
G962	G	Linear or revolutional feedrate and constant cutting rate	m	+		*PGs/*
G971	G	Freeze spindle speed and linear feedrate	m	+		*PGs/*
G972	G	Freeze linear or revolutional feedrate and constant spindle speed	m	+		*PGs/*
G973	G	Revolutional feedrate without spindle speed limitation	m	+		*PGs/*
GEOAX	P	Assign new channel axes to geometry axes 1 - 3		+	-	*PGAs/* Replaceable geometry axes (GEOAX) (Page 585)
GET	P	Replace enabled axis between channels		+	+	*PGAs/* Axis replacement, spindle replacement (RELEASE, GET, GETD) (Page 132)
GETACTT	F	Gets active tool from a group of tools with the same name		+	-	*FBWs/*
GETACTTD	F	Gets the T number associated with an absolute D number		+	-	*PGAs/* Free assignment of D numbers: Determine T number to the specified D number (GETACTTD) (Page 426)
GETD	P	Replace axis directly between channels		+	-	*PGAs/* Axis replacement, spindle replacement (RELEASE, GET, GETD) (Page 132)
GETDNO	F	Returns the D number of a cutting edge (CE) of a tool (T)		+	-	*PGAs/* Free assignment of D numbers: Rename D numbers (GETDNO, SETDNO) (Page 425)
GETEXET	P	Reading of the loaded T number		+	-	*FBWs/*
GETFREELOC	P	Find a free space in the magazine for a given tool		+	-	*FBWs/*
GETSELT	P	Return selected T number		+	-	*FBWs/*

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
GETT	F	Get T number for tool name		+	-	*FBWsl*
GETTCOR	F	Read out tool lengths and/or tool length components		+	-	*FB1sl (W1)*
GETTENV	F	Read T, D and DL numbers		+	-	*FB1sl (W1)*
GETVARAP	F	Read access rights to a system/user variable		+	-	*PGAsl* Read attribute values / data type (GETVARPHU, GETVARAP, GETVARLIM, GETVARDFT, GETVARTYP) (Page 56)
GETVARDFT	F	Read default value of a system/user variable		+	-	*PGAsl* Read attribute values / data type (GETVARPHU, GETVARAP, GETVARLIM, GETVARDFT, GETVARTYP) (Page 56)
GETVARLIM	F	Read limit values of a system/user variable		+	-	*PGAsl* Read attribute values / data type (GETVARPHU, GETVARAP, GETVARLIM, GETVARDFT, GETVARTYP) (Page 56)
GETVARPHU	F	Read physical unit of a system/user variable		+	-	*PGAsl* Read attribute values / data type (GETVARPHU, GETVARAP, GETVARLIM, GETVARDFT, GETVARTYP) (Page 56)
GETVARTYP	F	Read data type of a system/user variable		+	-	*PGAsl* Read attribute values / data type (GETVARPHU, GETVARAP, GETVARLIM, GETVARDFT, GETVARTYP) (Page 56)
GOTO	K	Jump operation first forward then backward (direction initially to end of program and then to beginning of program)		+		*PGAsl* Program jumps to jump markers (GOTOB, GOTOF, GOTO, GOTOC) (Page 97)
GOTOB	K	Jump backward (toward the beginning of the program)		+		*PGAsl* Program jumps to jump markers (GOTOB, GOTOF, GOTO, GOTOC) (Page 97)
GOTOC	K	As GOTO, but suppress alarm 14080 "Jump destination not found"		+		*PGAsl* Program jumps to jump markers (GOTOB, GOTOF, GOTO, GOTOC) (Page 97)
GOTOF	K	Jump forward (toward the end of the program)		+		*PGAsl* Program jumps to jump markers (GOTOB, GOTOF, GOTO, GOTOC) (Page 97)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
GOTOS	K	Jump back to beginning of program		+		*PGAsl* Return jump to the start of the program (GOTOS) (Page 96)
GP	K	Keyword for the indirect programming of position attributes		+		*PGAsl* Indirectly programming position attributes (GP) (Page 65)
GWPSOF	P	Deselect constant grinding wheel peripheral speed (GWPS)	s	+	-	*PGsl*
GWPSON	P	Select constant grinding wheel peripheral speed (GWPS)	s	+	-	*PGsl*
H...	A	Auxiliary function output to the PLC		+	+	*PGsl/FB1sl (H2)*
HOLES1	C	Row of holes		+		*PGAsl* Row of holes - HOLES1 (Page 657)
HOLES2	C	Circle of holes		+		*PGAsl*
I	A	Interpolation parameters	s	+		*PGsl*
I1	A	Intermediate point coordinate	s	+		*PGsl*
IC	K	Incremental dimensions	s	+		*PGsl*
ICYCOF	P	All blocks of a technology cycle are processed in one interpolation cycle following ICYCOF		+	+	*FBSY*
ICYCON	P	Each block of a technology cycle is processed in a separate interpolation cycle following ICYCON		+	+	*FBSY*
ID	K	Identifier for modal synchronized actions	m	-	+	*FBSY*
IDS	K	Identifier for modal static synchronized actions		-	+	*FBSY*
IF	K	Introduction of a conditional jump in the part program/technology cycle		+	+	*PGAsl* Conditional statement and branch (IF, ELSE, ENDIF) (Page 110)
INDEX	F	Define index of character in input string		+	-	*PGAsl* Search for character/string in the string (INDEX, RINDEX, MINDEX, MATCH) (Page 83)
INICF	K	Initialization of variables at NewConfig		+		*PGAsl* Definition of user variables (DEF) (Page 24)
INIPO	K	Initialization of variables at POWER ON		+		*PGAsl* Definition of user variables (DEF) (Page 24)
INIRE	K	Initialization of variables at reset		+		*PGAsl* Definition of user variables (DEF) (Page 24)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
INIT	P	Selection of a particular NC program for execution in a particular channel		+	-	*PGAsl* Program coordination (INIT, START, WAITM, WAITMC, WAITE, SETM, CLEARM) (Page 116)
INITIAL		Generation of an INI file across all areas		+		*PGAsl* Working memory (CHANDATA, COMPLETE, INITIAL) (Page 213)
INT	K	Data type: Integer with sign		+		*PGAsl* Definition of user variables (DEF) (Page 24)
INTERSEC	F	Calculate intersection between two contour elements		+	-	*PGAsl* Determine point of intersection between two contour elements (INTERSEC) (Page 635)
INTTOAX	F	Converting a data type of an axis variable from INT to AXIS		+	-	*PGAsl* Explicit data type conversions (AXTOINT, INTTOAX) (Page 53)
INVCCW	G	Trace involute, counter-clockwise	m	+		*PGsl*
INVCW	G	Trace involute, clockwise	m	+		*PGsl*
INVFRAME	F	Calculate the inverse frame from a frame		+	-	*FB1sl (K2)*
IP	K	Variable interpolation parameter		+		*PGAsl* Indirect programming (Page 61)
IPOBRKA	P	Motion criterion from braking ramp activation	m	+	+	
IPOENDA	K	End of motion when “IPO stop” reached	m	+		*PGAsl* Programmable end of motion criteria (FINEA, COARSEA, IPOENDA, IPOBRKA, ADISPOSA) (Page 268)
IPTRLOCK	P	Freeze start of the untraceable program section at next machine function block.	m	+	-	*PGAsl* Prevent program position for SERUPRO (IPTRLOCK, IPTRUNLOCK) (Page 474)
IPTRUNLOCK	P	Set end of untraceable program section at current block at time of interruption.	m	+	-	*PGAsl* Prevent program position for SERUPRO (IPTRLOCK, IPTRUNLOCK) (Page 474)
ISAXIS	F	Check if geometry axis 1 specified as parameter		+	-	*PGAsl* Axis functions (AXNAME, AX, SPI, AXTOSPI, ISAXIS, AXSTRING, MODAXVAL) (Page 583)
ISD	A	Insertion depth	m	+		*PGAsl* Activating 3D tool offsets (CUT3DC, CUT3DF, CUT3DFS, CUT3DFF, ISD) (Page 404)
ISFILE	F	Check whether the file exists in the NCK application memory		+	-	*PGAsl* Check for presence of file (ISFILE) (Page 148)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
ISNUMBER	F	Check whether the input string can be converted to a number		+	-	*PGAsl* Type conversion from STRING (NUMBER, ISNUMBER, AXNAME) (Page 79)
ISOCALL	K	Indirect call of a program programmed in an ISO language		+		*PGAsl* Indirect call of a program programmed in ISO language (ISOCALL) (Page 195)
ISVAR	F	Check whether the transfer parameter contains a variable declared in the NC		+	-	*PGAsl* Check availability of a variable (ISVAR) (Page 54)
J	A	Interpolation parameters	s	+		*PGsl*
J1	A	Intermediate point coordinate	s	+		*PGsl*
JERKA	P	Activate acceleration response set via MD for programmed axes		+	-	
JERKLIM	K	Reduction or overshoot of maximum axial jerk	m	+		*PGAsl* Percentage jerk correction (JERKLIM) (Page 484)
JERKLIMA	K	Reduction or overshoot of maximum axial jerk	m	+	+	*PGAsl* Influence of acceleration on following axes (VELOLIMA, ACCLIMA, JERKLIMA) (Page 459)
K	A	Interpolation parameters	s	+		*PGsl*
K1	A	Intermediate point coordinate	s	+		*PGsl*
KONT	G	Travel around contour on tool offset	m	+		*PGsl*
KONTC	G	Approach/retract with continuous-curvature polynomial	m	+		*PGsl*
KONTT	G	Approach/retract with continuous-tangent polynomial	m	+		*PGsl*
L	A	Subprogram number	s	+	+	*PGAsl* Subprogram call without parameter transfer (Page 184)
LEAD	A	Lead angle 1. Tool orientation 2. Orientation polynomial	m	+		*PGAsl* Programming the tool orientation (A..., B..., C..., LEAD, TILT) (Page 313)
LEADOF	P	Axial master value coupling OFF		+	+	*PGAsl* Axial master value coupling (LEADON, LEADOF) (Page 518)
LEADON	P	Axial master value coupling on		+	+	*PGAsl* Axial master value coupling (LEADON, LEADOF) (Page 518)
LENTOAX	F	Provides information about the assignment of tool lengths L1, L2, and L3 of the active tool to the abscissa, ordinate and applicate		+	-	*FB1sl (W1)*

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
LFOF [6]	G	Fast retraction for thread cutting OFF	m	+		*PGsl*
LFON	G	Fast retraction for thread cutting ON	m	+		*PGsl*
LFPOS	G	Retraction of the axis declared with POLFMASK or POLFMLIN to the absolute axis position programmed with POLF	m	+		*PGsl*
LFTXT [6]	G	The plane of the retraction movement for fast retraction is determined from the path tangent and the current tool direction	m	+		*PGsl*
LFWP	G	The plane of the retraction movement for fast retraction is determined by the current working plane (G17/G18/G19)	m	+		*PGsl*
LIFTFAST	K	Fast retraction		+		*PGsl* Fast retraction from the contour (SETINT LIFTFAST, ALF) (Page 127)
LIMS	K	Speed limitation for G96/G961 and G97	m	+		*PGsl*
LLI	K	Lower limit value of variables		+		*PGAsl* Attribute: Limit values (LLI, ULI) (Page 35)
LN	F	Natural logarithm		+	+	*PGAsl* Arithmetic functions (Page 69)
LOCK	P	Disable synchronized action with ID (stop technology cycle)		-	+	*FBSY*
LONGHOLE	C	Elongated hole		+		*PGAsl* Elongated hole - LONGHOLE (Page 679)
LOOP	K	Introduction of an endless loop		+		*PGAsl* Continuous program loop (LOOP, ENDLOOP) (Page 111)
M0		Programmed stop		+	+	*PGsl*
M1		Optional stop		+	+	*PGsl*
M2		End of program, main program (as M30)		+	+	*PGsl*
M3		CW spindle rotation		+	+	*PGsl*
M4		CCW spindle rotation		+	+	*PGsl*
M5		Spindle stop		+	+	*PGsl*
M6		Tool change		+	+	*PGsl*
M17		End of subprogram		+	+	*PGsl*
M19		Spindle positioning to the position entered in SD43240		+	+	*PGsl*

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
M30		End of program, main program (as M2)		+	+	*PGs/*
M40		Automatic gear change		+	+	*PGs/*
M41 ... M45		Gear stage 1 ... 5		+	+	*PGs/*
M70		Transition to axis mode		+	+	*PGs/*
MASLDEF	P	Define master/slave axis grouping		+	+	*PGAs/* Master/slave coupling (MASLDEF, MASLDEL, MASLON, MASLOF, MASLOFS) (Page 549)
MASLDEL	P	Uncouple master/slave axis grouping and clear grouping definition		+	+	*PGAs/* Master/slave coupling (MASLDEF, MASLDEL, MASLON, MASLOF, MASLOFS) (Page 549)
MASLOF	P	Deactivation of a temporary coupling		+	+	*PGAs/* Master/slave coupling (MASLDEF, MASLDEL, MASLON, MASLOF, MASLOFS) (Page 549)
MASLOFS	P	Deactivation of a temporary coupling with automatic slave axis stop		+	+	*PGAs/* Master/slave coupling (MASLDEF, MASLDEL, MASLON, MASLOF, MASLOFS) (Page 549)
MASLON	P	Activation of a temporary coupling		+	+	*PGAs/* Master/slave coupling (MASLDEF, MASLDEL, MASLON, MASLOF, MASLOFS) (Page 549)
MATCH	F	Search for string in string		+	-	*PGAs/* Search for character/string in the string (INDEX, RINDEX, MINDEX, MATCH) (Page 83)
MAXVAL	F	Larger value of two variables (arithm. function)		+	+	*PGAs/* Variable minimum, maximum and range (MINVAL, MAXVAL and BOUND) (Page 74)
MCALL	K	Modal subprogram call		+		*PGAs/* Modal subprogram call (MCALL) (Page 191)
MEAC	K	Continuous axial measurement without delete distance-to-go	s	+	+	*PGAs/* Axial measurement (MEASA, MEAWA, MEAC) (option) (Page 256)
MEAFRAME	F	Frame calculation from measuring points		+	-	*PGAs/* Frame calculation from three measuring points in space (MEAFRAME) (Page 288)
MEAS	A	Measurement with delete distance-to-go	s	+		*PGAs/* Measuring with touch-trigger probe (MEAS, MEAW) (Page 253)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
MEASA	K	Axial measurement with delete distance-to-go	s	+	+	*PGAsl* Axial measurement (MEASA, MEAWA, MEAC) (option) (Page 256)
MEASURE	F	Calculation method for workpiece and tool measurement		+	-	*FB1sl (M5)* Measuring with touch-trigger probe (MEAS, MEAW) (Page 253)
MEAW	A	Measurement without delete distance-to-go	s	+		*PGAsl* Measuring with touch-trigger probe (MEAS, MEAW) (Page 253)
MEAWA	K	Axial measurement without delete distance-to-go	s	+	+	*PGAsl* Axial measurement (MEASA, MEAWA, MEAC) (option) (Page 256)
MI	K	Access to frame data: Mirroring		+		*PGAsl* Reading and changing frame components (TR, FI, RT, SC, MI) (Page 280)
MINDEX	F	Define index of character in input string		+	-	*PGAsl* Search for character/string in the string (INDEX, RINDEX, MINDEX, MATCH) (Page 83)
MINVAL	F	Smaller value of two variables (arithm. function)		+	+	*PGAsl* Variable minimum, maximum and range (MINVAL, MAXVAL and BOUND) (Page 74)
MIRROR	G	Programmable mirroring	s	+		*PGAsl*
MMC	P	Call the dialog window interactively from the part program on the HMI		+	-	*PGAsl* Interactively call the window from the part program (MMC) (Page 598)
MOD	K	Modulo division		+		*PGAsl* Arithmetic functions (Page 69)
MODAXVAL	F	Determine modulo position of a modulo rotary axis		+	-	*PGAsl* Axis functions (AXNAME, AX, SPI, AXTOSPI, ISAXIS, AXSTRING, MODAXVAL) (Page 583)
MOV	K	Start positioning axis		-	+	*FBSY*
MOVT	A	Specify end point of a traversing motion in the tool direction				*FB1(K2)*
MSG	P	Programmable messages	m	+	-	*PGsl*
MVTOOL	P	Language command to move tool		+	-	*FBWsl*
N	A	NC auxiliary block number		+		*PGsl*
NAMETOINT	F	Determining the system variable index		+		*PGAsl* Index determination by means of names (NAMETOINT) (Page 377)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
NCK	K	Specify validity range for data		+		*PGAs/* Definition of user variables (DEF) (Page 24)
NEWCONF	P	Apply modified machine data (corresponds to "Activate machine data")		+	-	*PGAs/* Activate machine data (NEWCONF) (Page 138)
NEWMT	F	Create new multitool		+	-	*FBWs/*
NEWT	F	Create new tool		+	-	*FBWs/*
NORM [6]	G	Standard setting in starting point and end point with tool offset	m	+		*PGs/*
NOT	K	Logic NOT (negation)		+		*PGAs/* Comparison and logic operations (Page 71)
NPROT	P	Machine-specific protection zone ON/OFF		+	-	*PGAs/* Activating/deactivating protection zones (CPROT, NPROT) (Page 220)
NPROTDEF	P	Definition of a machine-specific protection zone		+	-	*PGAs/* Defining the protection zones (CPROTDEF, NPROTDEF) (Page 217)
NUMBER	F	Convert input string to number		+	-	*PGAs/* Type conversion from STRING (NUMBER, ISNUMBER, AXNAME) (Page 79)
OEMIPO1	G	OEM interpolation 1	m	+		*PGAs/* Special functions for OEM users (OMA1 ... OMA5, OEMIPO1, OEMIPO2, G810 ... G829) (Page 266)
OEMIPO2	G	OEM interpolation 2	m	+		*PGAs/* Special functions for OEM users (OMA1 ... OMA5, OEMIPO1, OEMIPO2, G810 ... G829) (Page 266)
OF	K	Keyword in CASE branch		+		*PGAs/* Program branch (CASE ... OF ... DEFAULT ...) (Page 100)
OFFN	A	Allowance on the programmed contour	m	+		*PGs/*
OMA1	A	OEM address 1	m	+		*PGAs/* Special functions for OEM users (OMA1 ... OMA5, OEMIPO1, OEMIPO2, G810 ... G829) (Page 266)
OMA2	A	OEM address 2	m	+		*PGAs/* Special functions for OEM users (OMA1 ... OMA5, OEMIPO1, OEMIPO2, G810 ... G829) (Page 266)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
OMA3	A	OEM address 3	m	+		*PGAsl* Special functions for OEM users (OMA1 ... OMA5, OEMIPO1, OEMIPO2, G810 ... G829) (Page 266)
OMA4	A	OEM address 4	m	+		*PGAsl* Special functions for OEM users (OMA1 ... OMA5, OEMIPO1, OEMIPO2, G810 ... G829) (Page 266)
OMA5	A	OEM address 5	m	+		*PGAsl* Special functions for OEM users (OMA1 ... OMA5, OEMIPO1, OEMIPO2, G810 ... G829) (Page 266)
OR	K	Logic operator, OR operation		+		*PGAsl* Comparison and logic operations (Page 71)
ORIAXES	G	Linear interpolation of machine axes or orientation axes	m	+		*PGAsl* Programming orientation axes (ORIAXES, ORIVECT, ORIEULER, ORIRPY, ORIRPY2, ORIVIRT1, ORIVIRT2) (Page 323)
ORIAXPOS	G	Orientation angle via virtual orientation axes with rotary axis positions	m	+		*PGAsl* Programming the tool orientation (A..., B..., C..., LEAD, TILT) (Page 313)
ORIC [6]	G	Orientation changes at outside corners are overlaid on the circle block to be inserted	m	+		*PGAsl* Tool orientation (ORIC, ORID, OSOF, OSC, OSS, OSSE, ORIS, OSD, OST) (Page 418)
ORICONCCW	G	Interpolation on a circular peripheral surface in CCW direction	m	+		*PGAsl/FB3sl (F3)* Orientation programming along the peripheral surface of a taper (ORIPLANE, ORICONCW, ORICONCCW, ORICONTO, ORICONIO) (Page 326)
ORICONCW	G	Interpolation on a circular peripheral surface in CW direction	m	+		*PGAsl/FB3sl (F4)* Orientation programming along the peripheral surface of a taper (ORIPLANE, ORICONCW, ORICONCCW, ORICONTO, ORICONIO) (Page 326)
ORICONIO	G	Interpolation on a circular peripheral surface with intermediate orientation setting	m	+		*PGAsl/FB3sl (F4)* Orientation programming along the peripheral surface of a taper (ORIPLANE, ORICONCW, ORICONCCW, ORICONTO, ORICONIO) (Page 326)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
ORICONTO	G	Interpolation on circular peripheral surface in tangential transition (final orientation)	m	+		*PGAsl/FB3sl (F5)* Orientation programming along the peripheral surface of a taper (ORIPLANE, ORICONCW, ORICONCCW, ORICONTO, ORICONIO) (Page 326)
ORICURVE	G	Interpolation of orientation with specification of motion of two contact points of tool	m	+		*PGAsl/FB3sl (F6)* Specification of orientation for two contact points (ORICURVE, PO[XH]=, PO[YH]=, PO[ZH]=) (Page 329)
ORID	G	Orientation changes are performed before the circle block	m	+		*PGAsl* Tool orientation (ORIC, ORID, OSOF, OSC, OSS, OSSE, ORIS, OSD, OST) (Page 418)
ORIEULER [6]	G	Orientation angle via Euler angle	m	+		*PGAsl* Programming orientation axes (ORIAXES, ORIVECT, ORIEULER, ORIRPY, ORIRPY2, ORIVIRT1, ORIVIRT2) (Page 323)
ORIMKS	G	Tool orientation in the machine coordinate system	m	+		*PGAsl* Reference of the orientation axes (ORIWKS, ORIMKS): (Page 321)
ORIPATH	G	Tool orientation in relation to path	m	+		*PGAsl* Rotation of the tool orientation relative to the path (ORIPATH, ORIPATHS, angle of rotation) (Page 337)
ORIPATHS	G	Tool orientation in relation to path, blips in the orientation characteristic are smoothed	m	+		*PGAsl* Rotation of the tool orientation relative to the path (ORIPATH, ORIPATHS, angle of rotation) (Page 337)
ORIPLANE	G	Interpolation in a plane (corresponds to ORIVECT), large-radius circular interpolation	m	+		*PGAsl* Orientation programming along the peripheral surface of a taper (ORIPLANE, ORICONCW, ORICONCCW, ORICONTO, ORICONIO) (Page 326)
ORIRESET	P	Initial tool orientation with up to 3 orientation axes		+	-	*PGAsl* Variants of orientation programming and initial setting (ORIRESET) (Page 311)
ORIROTA [6]	G	Angle of rotation to an absolute direction of rotation	m	+		*PGAsl* Rotations of the tool orientation (ORIROTA, ORIROTR, ORIROTT, ORIROTC, THETA) (Page 333)
ORIROTC	G	Tangential rotational vector in relation to path tangent	m	+		*PGAsl* Rotations of the tool orientation (ORIROTA, ORIROTR, ORIROTT, ORIROTC, THETA) (Page 333)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
ORIROTR	G	Angle of rotation relative to the plane between the start and end orientation	m	+		*PGAs!* Rotations of the tool orientation (ORIROTA, ORIROTR, ORIROTT, ORIROTC, THETA) (Page 333)
ORIROTT	G	Angle of rotation relative to the change in the orientation vector	m	+		*PGAs!* Rotations of the tool orientation (ORIROTA, ORIROTR, ORIROTT, ORIROTC, THETA) (Page 333)
ORIRPY	G	Orientation angle via RPY angle (XYZ)	m	+		*PGAs!* Programming orientation axes (ORIAXES, ORIVECT, ORIEULER, ORIRPY, ORIRPY2, ORIVIRT1, ORIVIRT2) (Page 323)
ORIRPY2	G	Orientation angle via RPY angle (ZYX)	m	+		*PGAs!* Programming orientation axes (ORIAXES, ORIVECT, ORIEULER, ORIRPY, ORIRPY2, ORIVIRT1, ORIVIRT2) (Page 323)
ORIS	A	Change in orientation	m	+		*PGAs!* Tool orientation (ORIC, ORID, OSOF, OSC, OSS, OSSE, ORIS, OSD, OST) (Page 418)
ORISOF [6]	G	Smoothing of the orientation characteristic OFF	m	+		*PGAs!* Smoothing the orientation characteristic (ORISON, ORISOF) (Page 344)
ORISON	G	Smoothing of the orientation characteristic ON	m	+		*PGAs!* Smoothing the orientation characteristic (ORISON, ORISOF) (Page 344)
ORIVECT [6]	G	Large-radius circular interpolation (identical to ORIPLANE)	m	+		*PGAs!* Programming orientation axes (ORIAXES, ORIVECT, ORIEULER, ORIRPY, ORIRPY2, ORIVIRT1, ORIVIRT2) (Page 323)
ORIVIRT1	G	Orientation angle via virtual orientation axes (definition 1)	m	+		*PGAs!* Programming orientation axes (ORIAXES, ORIVECT, ORIEULER, ORIRPY, ORIRPY2, ORIVIRT1, ORIVIRT2) (Page 323)
ORIVIRT2	G	Orientation angle via virtual orientation axes (definition 1)	m	+		*PGAs!* Programming orientation axes (ORIAXES, ORIVECT, ORIEULER, ORIRPY, ORIRPY2, ORIVIRT1, ORIVIRT2) (Page 323)
ORIWKS [6]	G	Tool orientation in the workpiece coordinate system	m	+		*PGAs!* Reference of the orientation axes (ORIWKS, ORIMKS): (Page 321)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
OS	K	Oscillation on/off		+		*PGAs*/ Asynchronous oscillation (OS, OSP1, OSP2, OST1, OST2, OSCTRL, OSNSC, OSE, OSB) (Page 555)
OSB	K	Oscillating: Starting point	m	+		*FB1sl (P5)*
OSC	G	Continuous tool orientation smoothing	m	+		*PGAs*/ Tool orientation (ORIC, ORID, OSOF, OSC, OSS, OSSE, ORIS, OSD, OST) (Page 418)
OSCILL	K	Axis: 1 - 3 infeed axes	m	+		*PGAs*/ Oscillation controlled by synchronized actions (OSCILL) (Page 560)
OSCTRL	K	Oscillation options	m	+		*PGAs*/ Asynchronous oscillation (OS, OSP1, OSP2, OST1, OST2, OSCTRL, OSNSC, OSE, OSB) (Page 555)
OSD	G	Smoothing of tool orientation by specifying smoothing distance with SD	m	+		*PGAs*/ Tool orientation (ORIC, ORID, OSOF, OSC, OSS, OSSE, ORIS, OSD, OST) (Page 418)
OSE	K	Oscillation end position	m	+		*PGAs*/ Asynchronous oscillation (OS, OSP1, OSP2, OST1, OST2, OSCTRL, OSNSC, OSE, OSB) (Page 555)
OSNSC	K	Oscillating: Number of spark-out cycles	m	+		*PGAs*/ Asynchronous oscillation (OS, OSP1, OSP2, OST1, OST2, OSCTRL, OSNSC, OSE, OSB) (Page 555)
OSOF [6]	G	Tool orientation smoothing OFF	m	+		*PGAs*/ Asynchronous oscillation (OS, OSP1, OSP2, OST1, OST2, OSCTRL, OSNSC, OSE, OSB) (Page 555)
OSP1	K	Oscillating: Left reversal point	m	+		*PGAs*/ Asynchronous oscillation (OS, OSP1, OSP2, OST1, OST2, OSCTRL, OSNSC, OSE, OSB) (Page 555)
OSP2	K	Oscillation right reversal point	m	+		*PGAs*/ Asynchronous oscillation (OS, OSP1, OSP2, OST1, OST2, OSCTRL, OSNSC, OSE, OSB) (Page 555)
OSS	G	Tool orientation smoothing at end of block	m	+		*PGAs*/ Tool orientation (ORIC, ORID, OSOF, OSC, OSS, OSSE, ORIS, OSD, OST) (Page 418)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
OSSE	G	Tool orientation smoothing at start and end of block	m	+		*PGAs/* Tool orientation (ORIC, ORID, OSOF, OSC, OSS, OSSE, ORIS, OSD, OST) (Page 418)
OST	G	Smoothing of tool orientation by specifying angular tolerance in degrees with SD (maximum deviation from programmed orientation characteristic)	m	+		*PGAs/* Tool orientation (ORIC, ORID, OSOF, OSC, OSS, OSSE, ORIS, OSD, OST) (Page 418)
OST1	K	Oscillating: Stopping point in left reversal point	m	+		*PGAs/* Asynchronous oscillation (OS, OSP1, OSP2, OST1, OST2, OSCTRL, OSNSC, OSE, OSB) (Page 555)
OST2	K	Oscillating: Stopping point in right reversal point	m	+		*PGAs/* Asynchronous oscillation (OS, OSP1, OSP2, OST1, OST2, OSCTRL, OSNSC, OSE, OSB) (Page 555)
OTOL	K	Orientation tolerance for compressor functions, orientation smoothing and smoothing types		+		*PGAs/* Programmable contour/orientation tolerance (CTOL, OTOL, ATOL) (Page 488)
OVR	K	Speed offset	m	+		*PGAs/*
OVRA	K	Axial speed offset	m	+	+	*PGAs/*
OVRRAP	K	Rapid traverse override	m	+		*PGAs/*
P	A	Number of subprogram cycles		+		*PGAs/* Number of program repetitions (P) (Page 189)
PAROT	G	Align workpiece coordinate system on workpiece	m	+		*PGs/*
PAROTOF [6]	G	Deactivate frame rotation in relation to workpiece	m	+		*PGs/*
PCALL	K	Call subprograms with absolute path and parameter transfer		+		*PGAs/* Call subprogram with path specification and parameters (PCALL) (Page 196)
PDELAYOF	G	Punching with delay OFF	m	+		*PGAs/* Punching and nibbling on or off (SPOF, SON, PON, SONS, PONS, PDELAYON, PDELAYOF, PUNCHACC) (Page 569)
PDELAYON [6]	G	Punching with delay ON	m	+		*PGAs/* Punching and nibbling on or off (SPOF, SON, PON, SONS, PONS, PDELAYON, PDELAYOF, PUNCHACC) (Page 569)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
PHI	K	Angle of rotation of the orientation around the direction axis of the taper		+		*PGAs*/ Orientation programming along the peripheral surface of a taper (ORIPLANE, ORICONCW, ORICONCCW, ORICONTO, ORICONIO) (Page 326)
PHU	K	Physical unit of a variable		+		*PGAs*/ Definition of user variables (DEF) (Page 24)
PL	A	1. B spline: Node clearance 2. Polynomial interpolation: Length of the parameter interval for polynomial interpolation	s	+		*PGAs*/ 1. Spline interpolation (ASPLINE, BSPLINE, CSPLINE, BAUTO, BNAT, BTAN, EAUTO, ENAT, ETAN, PW, SD, PL) (Page 230) 2. Polynomial interpolation (POLY, POLYPATH, PO, PL) (Page 244)
PM	K	Per minute		+		*PGs*/
PO	K	Polynomial coefficient for polynomial interpolation	s	+		*PGAs*/ Polynomial interpolation (POLY, POLYPATH, PO, PL) (Page 244)
POCKET3	C	Technological cycle: Milling rectangular pocket		+		*PGAs*/ Milling a rectangular pocket - POCKET3 (Page 662)
POCKET4	C	Technological cycle: Milling circular pocket		+		*PGAs*/ Milling a circular pocket - POCKET4 (Page 665)
POLF	K	LIFTFAST retraction position	m	+		*PGs*/*PGAs*/
POLFA	P	Start retraction position of single axes with $AA_ESR_TRIGGER	m	+	+	*PGs*/
POLFMASK	P	Enable axes for retraction without a connection between the axes	m	+	-	*PGs*/
POLFMLIN	P	Enable axes for retraction with a linear connection between the axes	m	+	-	*PGs*/
POLY	G	Polynomial interpolation	m	+		*PGAs*/ Polynomial interpolation (POLY, POLYPATH, PO, PL) (Page 244)
POLYPATH	P	Polynomial interpolation can be selected for the AXIS or VECT axis groups	m	+	-	*PGAs*/ Polynomial interpolation (POLY, POLYPATH, PO, PL) (Page 244)
PON	G	Punching ON	m	+		*PGAs*/ Punching and nibbling on or off (SPOF, SON, PON, SONS, PONS, PDELAYON, PDELAYOF, PUNCHACC) (Page 569)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
PONS	G	Punching ON in interpolation cycle	m	+		*PGAsl* Punching and nibbling on or off (SPOF, SON, PON, SONS, PONS, PDELAYON, PDELAYOF, PUNCHACC) (Page 569)
POS	K	Axis positioning		+	+	*PGsl*
POSA	K	Position axis across block boundary		+	+	*PGsl*
POSM	P	Position magazine		+	-	*FBWsl*
POSMT	P	Position multitool on toolholder at location number		+	-	*FBWsl*
POSP	K	Positioning in sections (oscillating)		+		*PGsl*
POSRANGE	F	Determine whether the currently interpolated position setpoint of an axis is located in a window at a predefined reference position		+	+	*FBSY*
POT	F	Square (arithmetic function)		+	+	*PGAsl* Arithmetic functions (Page 69)
PR	K	Per revolution		+		*PGsl*
PREPRO	PA	Identify subprograms with preparation		+		*PGAsl* Identifying subprograms with preparation (PREPRO) (Page 175)
PRESETON	P	Set actual values for programmed axes		+	+	*PGAsl* Orientation programming along the peripheral surface of a taper (ORIPLANE, ORICONCW, ORICONCCW, ORICONTO, ORICONIO) (Page 326)
PRIO	K	Keyword for setting the priority for interrupt processing		+		*PGAsl* Assign and start interrupt routine (SETINT, PRIO, BLSYNC) (Page 124)
PRLOC	K	Initialization of variables at reset only after local change		+		*PGAsl* Attribute: Initialization value (Page 32)
PROC	K	First operation in a program		+		*PGAsl* Call subprogram with path specification and parameters (PCALL) (Page 196)
PROTA	P	Request for a recalculation of the collision model		+		*PGAsl* Requesting a recalculation of the collision model (PROTA) (Page 380)
PROTD	F	Calculating the distance between two protection zones		+		*PGAsl* Setting the protection zone status (PROTS) (Page 382)
PROTS	P	Setting the protection zone status		+		*PGAsl* Determining the clearance of two protection zones (PROTD) (Page 383)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
PSI	K	Opening angle of the taper		+		*PGAs/* Orientation programming along the peripheral surface of a taper (ORIPLANE, ORICONCW, ORICONCCW, ORICONTO, ORICONIO) (Page 326)
PTP	G	Point-to-point motion	m	+		*PGAs/* Cartesian PTP travel (Page 362)
PTPG0	G	Point-to-point motion only with G0, otherwise CP	m	+		*PGAs/* PTP for TRANSMIT (Page 366)
PUNCHACC	P	Travel-dependent acceleration for nibbling		+	-	*PGAs/* Punching and nibbling on or off (SPOF, SON, PON, SONS, PONS, PDELAYON, PDELAYOF, PUNCHACC) (Page 569)
PUTFTOC	P	Tool fine offset for parallel dressing		+	-	*PGAs/* Online tool offset (PUTFTOCF, FCTDEF, PUTFTOC, FTOCON, FTOCOF) (Page 399)
PUTFTOCF	P	Tool fine offset dependent on a function for parallel dressing defined with FCTDEF		+	-	*PGAs/* Online tool offset (PUTFTOCF, FCTDEF, PUTFTOC, FTOCON, FTOCOF) (Page 399)
PW	A	B spline, point weight	s	+		*PGAs/* Spline interpolation (ASPLINE, BSPLINE, CSPLINE, BAUTO, BNAT, BTAN, EAUTO, ENAT, ETAN, PW, SD, PL) (Page 230)
QU	K	Fast additional (auxiliary) function output		+		*PGs/*
R...	A	Arithmetic parameter also as settable address identifier and with numerical extension		+		*PGAs/* Predefined user variables: Arithmetic parameters (R) (Page 20)
RAC	K	Absolute non-modal axis-specific radius programming	s	+		*PGs/*
RDISABLE	P	Read-in disable		-	+	*FBSY*
READ	P	Reads one or more lines in the specified file and stores the information read in the array		+	-	*PGAs/* Read lines in the file (READ) (Page 146)
REAL	K	Data type: Floating-point variable with sign (real numbers)		+		*PGAs/* Definition of user variables (DEF) (Page 24)
REDEF	K	Setting for machine data, NC language elements and system variables, specifying the user groups they are displayed for		+		*PGAs/* Redefinition of system variables, user variables, and NC language commands (REDEF) (Page 29)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
RELEASE	P	Release machine axes for axis exchange		+	+	*PGAsl* Axis replacement, spindle replacement (RELEASE, GET, GETD) (Page 132)
REP	K	Keyword for initialization of all elements of an array with the same value		+		*PGAsl* Definition and initialization of array variables (DEF, SET, REP) (Page 45)
REPEAT	K	Repetition of a program loop		+		*PGAsl* Repeat program section (REPEAT, REPEATB, ENDLABEL, P) (Page 102)
REPEATB	K	Repetition of a program line		+		*PGAsl* Repeat program section (REPEAT, REPEATB, ENDLABEL, P) (Page 102)
REPOSA	G	Linear repositioning with all axes	s	+		*PGAsl* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)
REPOSH	G	Repositioning with semicircle	s	+		*PGAsl* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)
REPOSHA	G	Repositioning with all axes; geometry axes in semicircle	s	+		*PGAsl* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)
REPOSL	G	Linear repositioning	s	+		*PGAsl* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)
REPOSQ	G	Repositioning in a quadrant	s	+		*PGAsl* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)
REPOSQA	G	Linear repositioning with all axes, geometry axes in quadrant	s	+		*PGAsl* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
RESET	P	Reset technology cycle		-	+	*FBSY*
RESETMON	P	Language command for setpoint activation		+	-	*FBWsl*
RET	P	End of subprogram		+	+	*PGAsl* Parameterizable subprogram return jump (RET ...) (Page 178)
RIC	K	Relative non-modal axis-specific radius programming	s	+		*PGsl* Axis replacement, spindle replacement (RELEASE, GET, GETD) (Page 132)
RINDEX	F	Define index of character in input string		+	-	*PGAsl* Search for character/string in the string (INDEX, RINDEX, MINDEX, MATCH) (Page 83)
RMB	G	Repositioning to start of block	m	+		*PGAsl* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)
RMBBL	G	Repositioning to start of block	s	+		*PGAsl* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)
RME	G	Repositioning to end of block	m	+		*PGAsl* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)
RMEBL	G	Repositioning to end of block	s	+		*PGAsl* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)
RMI [6]	G	Repositioning to interrupt point	m	+		*PGAsl* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
RMIBL [6]	G	Repositioning to interrupt point	s	+		*PGAsl* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)
RMN	G	Repositioning to the nearest path point	m	+		*PGAsl* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)
RMNBL	G	Repositioning to the nearest path point	s	+		*PGAsl* Repositioning to the contour (REPOSA, REPOSL, REPOSQ, REPOSQA, REPOSH, REPOSHA, DISR, DISPR, RMIBL, RMBBL, RMEBL, RMNBL) (Page 476)
RND	A	Round the contour corner	s	+		*PGsl*
RNDM	A	Modal rounding	m	+		*PGsl*
ROT	G	Programmable rotation	s	+		*PGsl*
ROTS	G	Programmable frame rotations with solid angles	s	+		*PGsl*
ROUND	F	Rounding of decimal places		+	+	*PGAsl* Arithmetic functions (Page 69)
ROUNDUP	F	Rounding up of an input value		+	+	*PGAsl* Roundup (ROUNDUP) (Page 153)
RP	A	Polar radius	m/s	+		*PGsl*
RPL	A	Rotation in the plane	s	+		*PGsl*
RT	K	Parameter for access to frame data: Rotation		+		*PGAsl* Reading and changing frame components (TR, FI, RT, SC, MI) (Page 280)
RTLIOF	G	G0 without linear interpolation (single-axis interpolation)	m	+		*PGsl*
RTLION [6]	G	G0 with linear interpolation	m	+		*PGsl*
S	A	Spindle speed (with G4, G96/G961 different meaning)	m/s	+	+	*PGsl*
SAVE	PA	Attribute for saving information when subprograms are called		+		*PGAsl* Save modal G functions (SAVE) (Page 166)
SBLOF	P	Suppress single block		+	-	*PGAsl* Suppress single block execution (SBLOF, SBLON) (Page 167)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
SBLON	P	Revoke suppression of single block		+	-	*PGAsl* Suppress single block execution (SBLOF, SBLON) (Page 167)
SC	K	Parameter for access to frame data: Scaling		+		*PGAsl* Reading and changing frame components (TR, FI, RT, SC, MI) (Page 280)
SCALE	G	Programmable scaling	s	+		*PGsl*
SCC	K	Selective assignment of transverse axis to G96/G961/G962. Axis identifiers may take the form of geometry, channel or machine axes.		+		*PGsl*
SCPARA	K	Program servo parameter set		+	+	*PGAsl* Programmable parameter set changeover (SCPARA) (Page 593)
SD	A	Spline degree	s	+		*PGAsl* Spline interpolation (ASPLINE, BSPLINE, CSPLINE, BAUTO, BNAT, BTAN, EAUTO, ENAT, ETAN, PW, SD, PL) (Page 230)
SET	K	Keyword for initialization of all elements of an array with listed values		+		*PGAsl* Definition and initialization of array variables (DEF, SET, REP) (Page 45)
SETAL	P	Set alarm		+	+	*PGAsl* Alarms (SETAL) (Page 614)
SETDNO	F	Assign the D number of a cutting edge (CE) of a tool (T)		+	-	*PGAsl* Free assignment of D numbers: Rename D numbers (GETDNO, SETDNO) (Page 425)
SETINT	K	Define which interrupt routine is to be activated when an NCK input is present		+		*PGAsl* Assign and start interrupt routine (SETINT, PRIO, BLSYNC) (Page 124)
SETM	P	Setting of markers in dedicated channel		+	+	PGAsl Program coordination (INIT, START, WAITM, WAITMC, WAITE, SETM, CLEARM) (Page 116)
SETMS	P	Reset to the master spindle defined in machine data		+	-	
SETMS(n)	P	Set spindle n as master spindle		+		*PGsl*
SETMTH	P	Set master toolholder number		+	-	*FBWsl*
SETPIECE	P	Set piece number for all tools assigned to the spindle		+	-	*FBWsl*
SETTA	P	Activate tool from wear group		+	-	*FBWsl*

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
SETTCOR	F	Modification of tool components taking all supplementary conditions into account		+	-	*FB1sl (W1)*
SETTIA	P	Deactivate tool from wear group		+	-	*FBWsl*
SF	A	Starting point offset for thread cutting	m	+		*PGsl*
SIN	F	Sine (trigon. function)		+	+	*PGAsl* Arithmetic functions (Page 69)
SIRELAY	F	Activate the safety functions parameterized with SIRELIN, SIRELOUT, and SIRELTIME		-	+	*FBSIsl*
SIRELIN	P	Initialize input variables of function block		+	-	*FBSIsl*
SIRELOUT	P	Initialize output variables of function block		+	-	*FBSIsl*
SIRELTIME	P	Initialize timers of function block		+	-	*FBSIsl*
SLOT1	C	Technological cycle: Longitudinal groove		+		*PGAsl* Longitudinal slot - SLOT1 (Page 673)
SLOT2	C	Technological cycle: Circumferential groove		+		*PGAsl* Circumferential slot - SLOT2 (Page 675)
SOFT	G	Soft path acceleration	m	+		*PGsl* Acceleration mode (BRISK, BRISKA, SOFT, SOFTA, DRIVE, DRIVEA) (Page 457)
SOFTA	P	Activate jerk-limited axis acceleration for the programmed axes		+	-	*PGsl* Acceleration mode (BRISK, BRISKA, SOFT, SOFTA, DRIVE, DRIVEA) (Page 457)
SON	G	Nibbling ON	m	+		*PGAsl* Punching and nibbling on or off (SPOF, SON, PON, SONS, PONS, PDELAYON, PDELAYOF, PUNCHACC) (Page 569)
SONS	G	Nibbling ON in interpolation cycle	m	+		*PGAsl* Punching and nibbling on or off (SPOF, SON, PON, SONS, PONS, PDELAYON, PDELAYOF, PUNCHACC) (Page 569)
SPATH [6]	G	Path reference for FGROUP axes is arc length	m	+		*PGAsl* Settable path reference (SPATH, UPATH) (Page 250)
SPCOF	P	Switch master spindle or spindle(s) from position control to speed control	m	+	-	*PGsl*
SPCON	P	Switch master spindle or spindle(s) from speed control to position control	m	+	-	*PGAsl*

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
SPI	F	Converts spindle number into axis identifier		+	-	*PGAs/* Axis functions (AXNAME, AX, SPI, AXTOSPI, ISAXIS, AXSTRING, MODAXVAL) (Page 583)
SPIF1 [6]	G	Fast NCK inputs/outputs for punching/nibbling byte 1	m	+		*FB2sl (N4)*
SPIF2	G	Fast NCK inputs/outputs for punching/nibbling byte 2	m	+		*FB2sl (N4)*
SPLINEPATH	P	Define spline grouping		+	-	*PGAs/* Spline group (SPLINEPATH) (Page 240)
SPN	A	Number of path sections per block	s	+		*PGAs/* Automatic path segmentation (Page 574)
SPOF [6]	G	Stroke OFF, nibbling, punching OFF	m	+		*PGAs/* Punching and nibbling on or off (SPOF, SON, PON, SONS, PONS, PDELAYON, PDELAYOF, PUNCHACC) (Page 569)
SPOS	K	Spindle position	m	+	+	*PGs/*
SPOSA	K	Spindle position across block boundaries	m	+		*PGs/*
SPP	A	Length of a path section	m	+		*PGAs/* Automatic path segmentation (Page 574)
SPRINT	F	Returns an input string formatted		+		*PGAs/* Formatting a string (SPRINT) (Page 87)
SQRT	F	Square root (arithmetic function)		+	+	*PGAs/* Arithmetic functions (Page 69)
SR	A	Oscillation retraction path for synchronized action	s	+		*PGs/*
SRA	K	Oscillation retraction path with external input axial for synchronized action	m	+		*PGs/*
ST	A	Oscillation sparking-out time for synchronized action	s	+		*PGs/*
STA	K	Oscillation sparking-out time axial for synchronized action	m	+		*PGs/*
START	P	Start selected programs simultaneously in several channels from current program		+	-	*PGAs/* Program coordination (INIT, START, WAITM, WAITMC, WAITE, SETM, CLEARM) (Page 116)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
STARTFIFO [6]	G	Execute; fill preprocessing memory simultaneously	m	+		*PGAsl* Program sequence with preprocessing memory (STOPFIFO, STARTFIFO, FIFOCTRL, STOPRE) (Page 466)
STAT		Position of joints	s	+		*PGAsl* Cartesian PTP travel (Page 362)
STOLF	K	G0 tolerance factor	m	+		*PGAsl* Tolerance for G0 motion (STOLF) (Page 492)
STOPFIFO	G	Stop machining; fill preprocessing memory until STARTFIFO is detected, preprocessing memory is full or end of program	m	+		*PGAsl* Program sequence with preprocessing memory (STOPFIFO, STARTFIFO, FIFOCTRL, STOPRE) (Page 466)
STOPRE	P	Preprocessing stop until all prepared blocks in the main run are executed		+	-	*PGAsl* Program sequence with preprocessing memory (STOPFIFO, STARTFIFO, FIFOCTRL, STOPRE) (Page 466)
STOPREOF	P	Revoke preprocessing stop		-	+	*FBSY*
STRING	K	Data type: Character string		+		*PGAsl* Definition of user variables (DEF) (Page 24)
STRINGIS	F	Checks the present scope of NC language and the NC cycle names, user variables, macros, and label names belonging specifically to this command to establish whether these exist, are valid, defined or active.		+	-	*PGAsl* Check scope of NC language present (STRINGIS) (Page 594)
STRLEN	F	Define string length		+	-	*PGAsl* Determine length of string (STRLEN) (Page 83)
SUBSTR	F	Define index of character in input string		+	-	*PGAsl* Selection of a substring (SUBSTR) (Page 85)
SUPA	G	Suppression of current zero offset, including programmed offsets, system frames, handwheel offsets (DRF), external zero offset, and overlaid movement	s	+		*PGsl*
SVC	K	Tool cutting rate	m	+		*PGsl*
SYNFCT	P	Evaluation of a polynomial as a function of a condition in the motion-synchronous action		-	+	*FBSY*
SYNR	K	The variable is read synchronously, i.e. at the time of execution		+		*PGAsl* Definition of user variables (DEF) (Page 24)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
SYNRW	K	The variable is read and written synchronously, i.e. at the time of execution		+		*PGAs/* Definition of user variables (DEF) (Page 24)
SYNW	K	The variable is written synchronously, i.e. at the time of execution		+		*PGAs/* Definition of user variables (DEF) (Page 24)
T	A	Call tool (only change if specified in machine data; otherwise M6 command necessary)		+		*PGs/*
TAN	F	Tangent (trigon. function)		+	+	*PGAs/* Arithmetic functions (Page 69)
TANG	P	Definition of axis grouping tangential correction		+	-	*PGAs/* Tangential control (TANG, TANGON, TANGOF, TLIFT, TANGDEL) (Page 445)
TANGDEL	P	Deletion of definition of axis grouping tangential correction		+	-	*PGAs/* Tangential control (TANG, TANGON, TANGOF, TLIFT, TANGDEL) (Page 445)
TANGOF	P	Tangential correction OFF		+	-	*PGAs/* Tangential control (TANG, TANGON, TANGOF, TLIFT, TANGDEL) (Page 445)
TANGON	P	Tangential correction ON		+	-	*PGAs/* Tangential control (TANG, TANGON, TANGOF, TLIFT, TANGDEL) (Page 445)
TCA (828D: _TCA)	P	Tool selection/tool change irrespective of tool status		+	-	*FBWs/*
TCARR	A	Request toolholder (number "m")		+		*PGAs/* Tool length compensation for orientable toolholders (TCARR, TCOABS, TCOFR, TCOFRX, TCOFRY, TCOFRZ) (Page 433)
TCI	P	Load tool from buffer into magazine		+	-	*FBWs/*
TCOABS [6]	G	Determine tool length components from the current tool orientation	m	+		*PGAs/* Tool length compensation for orientable toolholders (TCARR, TCOABS, TCOFR, TCOFRX, TCOFRY, TCOFRZ) (Page 433)
TCOFR	G	Determine tool length components from the orientation of the active frame	m	+		*PGAs/* Tool length compensation for orientable toolholders (TCARR, TCOABS, TCOFR, TCOFRX, TCOFRY, TCOFRZ) (Page 433)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
TCOFRX	G	Determine tool orientation of an active frame on selection of tool, tool points in X direction	m	+		*PGAsl* Tool length compensation for orientable toolholders (TCARR, TCOABS, TCOFR, TCOFRX, TCOFRY, TCOFRZ) (Page 433)
TCOFRY	G	Determine tool orientation of an active frame on selection of tool, tool points in Y direction	m	+		*PGAsl* Tool length compensation for orientable toolholders (TCARR, TCOABS, TCOFR, TCOFRX, TCOFRY, TCOFRZ) (Page 433)
TCOFRZ	G	Determine tool orientation of an active frame on selection of tool, tool points in Z direction	m	+		*PGAsl* Tool length compensation for orientable toolholders (TCARR, TCOABS, TCOFR, TCOFRX, TCOFRY, TCOFRZ) (Page 433)
THETA	A	Angle of rotation	s	+		*PGAsl* Rotations of the tool orientation (ORIROTA, ORIROTR, ORIROTT, ORIROTC, THETA) (Page 333)
TILT	A	Tilt angle	m	+		*PGAsl* Programming the tool orientation (A..., B..., C..., LEAD, TILT) (Page 313)
TLIFT	P	In tangential control insert intermediate block at contour corners		+	-	*PGAsl* Tangential control (TANG, TANGON, TANGOF, TLIFT, TANGDEL) (Page 445)
TML	P	Tool selection with magazine location number		+	-	*FBWsl*
TMOF	P	Deselect tool monitoring		+	-	*PGAsl* Grinding-specific tool monitoring in the part program (TMON, TMOF) (Page 581)
TMON	P	Activate tool monitoring		+	-	*PGAsl* Grinding-specific tool monitoring in the part program (TMON, TMOF) (Page 581)
TO	K	Designates the end value in a FOR counter loop		+		*PGAsl* Count loop (FOR ... TO ..., ENDFOR) (Page 112)
TOFF	K	Tool length offset in the direction of the tool length component that is effective parallel to the geometry axis specified in the index.	m	+		*PGsl*
TOFFL	K	Tool length offset in the direction of the tool length component L1, L2 or L3	m	+		*PGsl*

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
TOFFOF	P	Deactivate online tool offset		+	-	*PGAs/* Online tool length compensation (TOFFON, TOFFOF) (Page 436)
TOFFON	P	Activate online tool length offset		+	-	*PGAs/* Online tool length compensation (TOFFON, TOFFOF) (Page 436)
TOFFR	A	Tool radius offset	m	+		*PGs/*
TOFRAME	G	Align the Z axis of the WCS parallel to the tool orientation by rotating the frame	m	+		*PGs/*
TOFRAMEX	G	Align the X axis of the WCS parallel to the tool orientation by rotating the frame	m	+		*PGs/*
TOFRAMEY	G	Align the Y axis of the WCS by rotating the frame parallel to the tool orientation	m	+		*PGs/*
TOFRAMEZ	G	As TOFRAME	m	+		*PGs/*
TOLOWER	F	Convert the letters of a string into lowercase		+	-	*PGAs/* Conversion to lower/upper case letters (TOLOWER, TOUPPER) (Page 82)
TOOLENV	F	Save current states which are of significance to the evaluation of the tool data stored in the memory		+	-	*FB1s/ (W1)*
TOOLGNT	F	Determine number of tools of a tool group		+	-	*FBWs/*
TOOLGT	F	Determine T number of a tool from a tool group		+	-	*FBWs/*
TOROT	G	Align the Z axis of the WCS parallel to the tool orientation by rotating the frame	m	+		*PGs/*
TOROTOF [6]	G	Frame rotations in tool direction OFF	m	+		*PGs/*
TOROTX	G	Align the X axis of the WCS parallel to the tool orientation by rotating the frame	m	+		*PGs/*
TOROTY	G	Align the Y axis of the WCS by rotating the frame parallel to the tool orientation	m	+		*PGs/*
TOROTZ	G	As TOROT	m	+		*PGs/*
TOUPPER	F	Convert the letters of a string into uppercase		+	-	*PGAs/* Conversion to lower/upper case letters (TOLOWER, TOUPPER) (Page 82)
TOWBCS	G	Wear values in the basic coordinate system (BCS)	m	+		*PGAs/* Coordinate system of the active machining operation (TOWSTD, TOWMCS, TOWWCS, TOWBCS, TOWTCS, TOWKCS) (Page 395)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
TOWKCS	G	Wear values in the coordinate system of the tool head for kinetic transformation (differs from machine coordinate system through tool rotation)	m	+		*PGAsl* Coordinate system of the active machining operation (TOWSTD, TOWMCS, TOWWCS, TOWBCS, TOWTCS, TOWKCS) (Page 395)
TOWMCS	G	Wear values in machine coordinate system	m	+		*PGAsl* Coordinate system of the active machining operation (TOWSTD, TOWMCS, TOWWCS, TOWBCS, TOWTCS, TOWKCS) (Page 395)
TOWSTD [6]	G	Initial setting value for offsets in tool length	m	+		*PGAsl* Coordinate system of the active machining operation (TOWSTD, TOWMCS, TOWWCS, TOWBCS, TOWTCS, TOWKCS) (Page 395)
TOWTCS	G	Wear values in the tool coordinate system (toolholder ref. point T at the toolholder)	m	+		*PGAsl* Coordinate system of the active machining operation (TOWSTD, TOWMCS, TOWWCS, TOWBCS, TOWTCS, TOWKCS) (Page 395)
TOWWCS	G	Wear values in workpiece coordinate system	m	+		*PGAsl* Coordinate system of the active machining operation (TOWSTD, TOWMCS, TOWWCS, TOWBCS, TOWTCS, TOWKCS) (Page 395)
TR	K	Offset component of a frame variable		+		*PGAsl* Reading and changing frame components (TR, FI, RT, SC, MI) (Page 280)
TRAANG	P	Transformation inclined axis		+	-	*PGAsl* Inclined axis (TRAANG) (Page 357)
TRACON	P	Cascaded transformation		+	-	*PGAsl* Chained transformations (TRACON, TRAFOOF) (Page 371)
TRACYL	P	Cylinder: Peripheral surface transformation		+	-	*PGAsl* Cylinder surface transformation (TRACYL) (Page 349)
TRAFOOF	P	Deactivate active transformations in the channel		+	-	*PGAsl* Chained transformations (TRACON, TRAFOOF) (Page 371)
TRAILOF	P	Asynchronous coupled motion OFF		+	+	*PGAsl* Coupled motion (TRAILON, TRAILOF) (Page 495)
TRAILON	P	Asynchronous coupled motion ON		+	+	*PGAsl* Coupled motion (TRAILON, TRAILOF) (Page 495)
TRANS	G	Programmable offset	s	+		*PGsl*

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
TRANSMIT	P	Pole transformation (face machining)		+	-	*PGAs*/ Milling on turned parts (TRANSMIT): (Page 347)
TRAORI	P	4-axis, 5-axis transformation, generic transformation		+	-	*PGAs*/ Three, four and five axis transformation (TRAORI) (Page 310)
TRUE	K	Logical constant: True		+		*PGAs*/ Definition of user variables (DEF) (Page 24)
TRUNC	F	Truncation of decimal places		+	+	*PGAs*/ Precision correction on comparison errors (TRUNC) (Page 73)
TU		Axis angle	s	+		*PGAs*/ Cartesian PTP travel (Page 362)
TURN	A	Number of turns for helix	s	+		*PGs*/
ULI	K	Upper limit value of variables		+		*PGAs*/ Attribute: Limit values (LLI, ULI) (Page 35)
UNLOCK	P	Enable synchronized action with ID (continue technology cycle)		-	+	*FBSY*
UNTIL	K	Condition for end of REPEAT loop		+		*PGAs*/ Program loop with condition at start of loop (WHILE, ENDWHILE) (Page 114)
UPATH	G	Path reference for FGROUP axes is curve parameter	m	+		*PGAs*/ Settable path reference (SPATH, UPATH) (Page 250)
VAR	K	Keyword: Type of parameter transfer		+		*PGAs*/ Subprogram call with parameter transfer (EXTERN) (Page 187)
VELOLIM	K	Reduction of the maximum axial velocity	m	+		*PGAs*/ Percentage velocity correction (VELOLIM) (Page 486)
VELOLIMA	K	Reduction or increase of the maximum axial velocity of the following axis	m	+	+	*PGAs*/ Influence of acceleration on following axes (VELOLIMA, ACCLIMA, JERKLIMA) (Page 459)
WAITC	P	Wait for the coupling block change criterion to be fulfilled for the axes/spindles		+	-	*PGAs*/ Program coordination (INIT, START, WAITM, WAITMC, WAITE, SETM, CLEARM) (Page 116)
WAITE	P	Wait for end of program in another channel.		+	-	*PGAs*/ Program coordination (INIT, START, WAITM, WAITMC, WAITE, SETM, CLEARM) (Page 116)

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
WAITENC	P	Wait for synchronized or restored axis positions		+	-	*PGAsl* Wait for valid axis position (WAITENC) (Page 592)
WAITM	P	Wait for marker in specified channel; terminate previous block with exact stop.		+	-	*PGAsl* Program coordination (INIT, START, WAITM, WAITMC, WAITE, SETM, CLEARM) (Page 116)
WAITMC	P	Wait for marker in specified channel; exact stop only if the other channels have not yet reached the marker.		+	-	*PGAsl* Program coordination (INIT, START, WAITM, WAITMC, WAITE, SETM, CLEARM) (Page 116)
WAITP	P	Wait for end of travel of the positioning axis		+	-	*PGsl*
WAITS	P	Wait for spindle position to be reached		+	-	*PGsl*
WALCS0 [6]	G	Workpiece coordinate system working area limitation deselected	m	+		*PGsl*
WALCS1	G	Workpiece coordinate system working area limitation group 1 active	m	+		*PGsl*
WALCS2	G	Workpiece coordinate system working area limitation group 2 active	m	+		*PGsl*
WALCS3	G	Workpiece coordinate system working area limitation group 3 active	m	+		*PGsl*
WALCS4	G	Workpiece coordinate system working area limitation group 4 active	m	+		*PGsl*
WALCS5	G	Workpiece coordinate system working area limitation group 5 active	m	+		*PGsl*
WALCS6	G	Workpiece coordinate system working area limitation group 6 active	m	+		*PGsl*
WALCS7	G	Workpiece coordinate system working area limitation group 7 active	m	+		*PGsl*
WALCS8	G	Workpiece coordinate system working area limitation group 8 active	m	+		*PGsl*
WALCS9	G	Workpiece coordinate system working area limitation group 9 active	m	+		*PGsl*
WALCS10	G	Workpiece coordinate system working area limitation group 10 active	m	+		*PGsl*
WALIMOF	G	BCS working area limitation OFF	m	+		*PGsl*

Operation	Type [1]	Meaning	W [2]	TP [3]	SA [4]	Description see [5]
[1] [2] [3] [4] [5] for explanations, see legend (Page 776).						
WALIMON [6]	G	BCS working area limitation ON	m	+		*PGs/*
WHEN	K	The action is executed cyclically when the condition is fulfilled.		-	+	*FBSY*
WHENEVER	K	The action is executed once whenever the condition is fulfilled.		-	+	*FBSY*
WHILE	K	Start of WHILE program loop		+		*PGAs/* Program loop with condition at start of loop (WHILE, ENDWHILE) (Page 114)
WRITE	P	Write text to file system. Appends a block to the end of the specified file.		+	-	*PGAs/* Write file (WRITE) (Page 139)
WRTPR	P	Delays the machining job without interrupting continuous-path mode		+	-	*PGAs/*
X	A	Axis name	m/s	+		*PGs/*
XOR	O	Logic exclusive OR		+		*PGAs/* Comparison and logic operations (Page 71)
Y	A	Axis name	m/s	+		*PGs/*
Z	A	Axis name	m/s	+		*PGs/*

Legend

[1] Type of operation:

A Address

Identifier to which a value is assigned (e.g. OVR=10). There are also some addresses that switch on or off a function without value assignment (e.g. CPLON and CPLOF).

C Technological cycle

Predefined part program in which a generally valid specific cycle (machining operation), such as tapping of a thread or milling a pocket, is programmed. The adaptation to a specific machine situation is realized via parameters that are transferred to the cycle during the call.

F Predefined function (supplies a return value)

The call of the predefined function can be an operand in an expression.

G G function

G functions are divided into function groups. Only one G function of a group can be programmed in a block. A G function can be either modal (until it is canceled by another function of the same group) or only effective for the block in which it is programmed (non-modal).

K Keyword

Identifier that defines the syntax of a block. No value is assigned to a keyword, and no NC function can be switched on/off with a keyword.

Examples: Control structures (IF, ELSE, ENDIF, WHEN, ...), program execution (GOTOB, GOTO, RET ...)

O Operator

Operator for a mathematical, comparison or logical operation

P Predefined procedure (does not supply a return value)

P Program attribute

A Program attributes are at the end of the definition line of a subprogram:
`PROC <program name>(...) <program attribute>`
They determine the behavior during execution of the subprogram.

2) Effectiveness of the operation:

m Modal

s Non-modal

3) Programmability in part program:

\+ Programmable

\- Not programmable

4) Programmability in synchronized actions:

\+ Programmable

\- Not programmable

T Programmable only in technology cycles

5) Reference to the document containing the detailed description of the operation:

PGsl Programming Manual, Fundamentals

PGAsl Programming Manual, Job Planning

BNMsl Programming Manual Measuring Cycles

BHDsl Operating Manual, Turning

BHFsl Operating Manual, Milling

FB1sl ( ) Function Manual, Basic Functions (with the alphanumeric abbreviation of the corresponding function description in brackets)

FB2sl ( ) Function Manual, Extended Functions (with the alphanumeric abbreviation of the corresponding function description in brackets)

FB3sl ( ) Function Manual, Special Functions (with the alphanumeric abbreviation of the corresponding function description in brackets)

FBSIsl Function Manual, Safety Integrated

FBSY Function Manual, Synchronized Actions

FBWsl Function Manual, Tool Management

6) Default setting at beginning of program (factory settings of the control, if nothing else programmed).

Figure 19-1 Legend for the list of operations

19.2 Operations: Availability for SINUMERIK 828D

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
:	●	●	●	●	●	●
*	●	●	●	●	●	●
+	●	●	●	●	●	●
-	●	●	●	●	●	●
<	●	●	●	●	●	●
<<	●	●	●	●	●	●
<=	●	●	●	●	●	●
=	●	●	●	●	●	●
>=	●	●	●	●	●	●
/	●	●	●	●	●	●
/0 … … /7	● ○	● ○	● ○	● ○	● ○	● ○
A	●	●	●	●	●	●
A2	-	-	-	-	-	-
A3	-	-	-	-	-	-
A4	-	-	-	-	-	-
A5	-	-	-	-	-	-
ABS	●	●	●	●	●	●
AC	●	●	●	●	●	●
ACC	●	●	●	●	●	●
ACCLIMA	●	●	●	●	●	●
ACN	●	●	●	●	●	●
ACOS	●	●	●	●	●	●
ACP	●	●	●	●	●	●
ACTBLOCNO	●	●	●	●	●	●
ADDFRAME	●	●	●	●	●	●
ADIS	●	●	●	●	●	●
ADISPOS	●	●	●	●	●	●
ADISPOSA	●	●	●	●	●	●
ALF	●	●	●	●	●	●
AMIRROR	●	●	●	●	●	●
AND	●	●	●	●	●	●
ANG	●	●	●	●	●	●
AP	●	●	●	●	●	●
APR	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
APRB	●	●	●	●	●	●
APRP	●	●	●	●	●	●
APW	●	●	●	●	●	●
APWB	●	●	●	●	●	●
APWP	●	●	●	●	●	●
APX	●	●	●	●	●	●
AR	●	●	●	●	●	●
AROT	●	●	●	●	●	●
AROTS	●	●	●	●	●	●
AS	●	●	●	●	●	●
ASCALE	●	●	●	●	●	●
ASIN	●	●	●	●	●	●
ASPLINE	-	○	-	○	-	○
ATAN2	●	●	●	●	●	●
ATOL	-	●	-	●	-	●
ATRANS	●	●	●	●	●	●
AUXFUDEL	●	●	●	●	●	●
AUXFUDELG	●	●	●	●	●	●
AUXFUMSEQ	●	●	●	●	●	●
AUXFUSYNC	●	●	●	●	●	●
AX	●	●	●	●	●	●
AXCTSWE	-	-	-	-	-	-
AXCTSWEC	-	-	-	-	-	-
AXCTSWED	-	-	-	-	-	-
AXIS	●	●	●	●	●	●
AXNAME	●	●	●	●	●	●
AXSTRING	●	●	●	●	●	●
AXTOCHAN	●	●	●	●	●	●
AXTOINT	●	●	●	●	●	●
AXTOSPI	●	●	●	●	●	●
B	●	●	●	●	●	●
B2	-	-	-	-	-	-
B3	-	-	-	-	-	-
B4	-	-	-	-	-	-
B5	-	-	-	-	-	-
B_AND	●	●	●	●	●	●
B_OR	●	●	●	●	●	●
B_NOT	●	●	●	●	●	●
B_XOR	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
BAUTO	-	○	-	○	-	○
BLOCK	●	●	●	●	●	●
BLSYNC	●	●	●	●	●	●
BNAT	-	○	-	○	-	○
BOOL	●	●	●	●	●	●
BOUND	●	●	●	●	●	●
BRISK	●	●	●	●	●	●
BRISKA	●	●	●	●	●	●
BSPLINE	-	○	-	○	-	○
BTAN	-	○	-	○	-	○
C	●	●	●	●	●	●
C2	-	-	-	-	-	-
C3	-	-	-	-	-	-
C4	-	-	-	-	-	-
C5	-	-	-	-	-	-
CAC	●	●	●	●	●	●
CACN	●	●	●	●	●	●
CACP	●	●	●	●	●	●
CALCDAT	●	●	●	●	●	●
CALCPOSI	●	●	●	●	●	●
CALL	●	●	●	●	●	●
CALLPATH	●	●	●	●	●	●
CANCEL	●	●	●	●	●	●
CASE	●	●	●	●	●	●
CDC	●	●	●	●	●	●
CDOF	●	●	●	●	●	●
CDOF2	●	●	●	●	●	●
CDON	●	●	●	●	●	●
CFC	●	●	●	●	●	●
CFIN	●	●	●	●	●	●
CFINE	●	●	●	●	●	●
CFTCP	●	●	●	●	●	●
CHAN	●	●	●	●	●	●
CHANDATA	●	●	●	●	●	●
CHAR	●	●	●	●	●	●
CHF	●	●	●	●	●	●
CHKDM	●	●	●	●	●	●
CHKDNO	●	●	●	●	●	●
CHR	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
CIC	●	●	●	●	●	●
CIP	●	●	●	●	●	●
CLEARM	-	-	-	-	-	-
CLRINT	●	●	●	●	●	●
CMIRROR	●	●	●	●	●	●
COARSEA	●	●	●	●	●	●
COLLPAIR	-	-	-	-	-	-
COMPCAD	-	○	-	○	-	○
COMPCURV	-	○	-	○	-	○
COMPLETE	●	●	●	●	●	●
COMPOF	-	○	-	○	-	○
COMPON	-	○	-	○	-	○
CONTDCON	●	●	●	●	●	●
CONTPRON	●	●	●	●	●	●
CORROF	●	●	●	●	●	●
COS	●	●	●	●	●	●
COUPDEF	○	-	○	-	○	-
COUPDEL	○	-	○	-	○	-
COUPOF	○	-	○	-	○	-
COUPOFS	○	-	○	-	○	-
COUPON	○	-	○	-	○	-
COUPONC	○	-	○	-	○	-
COUPRES	○	-	○	-	○	-
CP	●	●	●	●	●	●
CPBC	●	●	●	●	●	●
CPDEF	●	●	●	●	●	●
CPDEL	●	●	●	●	●	●
CPFMOF	●	●	●	●	●	●
CPFMON	●	●	●	●	●	●
CPFMSON	●	●	●	●	●	●
CPFPOS	●	●	●	●	●	●
CPFRS	●	●	●	●	●	●
CPLA	●	●	●	●	●	●
CPLCTID	●	●	●	●	●	●
CPLDEF	●	●	●	●	●	●
CPLDEL	●	●	●	●	●	●
CPLDEN	●	●	●	●	●	●
CPLINSC	●	●	●	●	●	●
CPLINTR	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
CPLNUM	●	●	●	●	●	●
CPLOF	●	●	●	●	●	●
CPLON	●	●	●	●	●	●
CPLOUTSC	●	●	●	●	●	●
CPLOUTTR	●	●	●	●	●	●
CPLPOS	●	●	●	●	●	●
CPLSETVAL	●	●	●	●	●	●
CPMALARM	●	●	●	●	●	●
CPMBRAKE	●	●	●	●	●	●
CPMPRT	●	●	●	●	●	●
CPMRESET	●	●	●	●	●	●
CPMSTART	●	●	●	●	●	●
CPMVDI	●	●	●	●	●	●
CPOF	●	●	●	●	●	●
CPON	●	●	●	●	●	●
CPRECOF	●	●	●	●	●	●
CPRECON	●	●	●	●	●	●
CPRES	●	●	●	●	●	●
CPROT	●	●	●	●	●	●
CPROTDEF	●	●	●	●	●	●
CPSETTYPE	●	●	●	●	●	●
CPSYNCOP	●	●	●	●	●	●
CPSYNCOP2	●	●	●	●	●	●
CPSYNCOV	●	●	●	●	●	●
CPSYNFIP	●	●	●	●	●	●
CPSYNFIP2	●	●	●	●	●	●
CPSYNFIV	●	●	●	●	●	●
CR	●	●	●	●	●	●
CROT	●	●	●	●	●	●
CROTS	●	●	●	●	●	●
CRPL	●	●	●	●	●	●
CSCALE	●	●	●	●	●	●
CSPLINE	-	○	-	○	-	○
CT	●	●	●	●	●	●
CTAB	-	-	-	-	-	-
CTABDEF	-	-	-	-	-	-
CTABDEL	-	-	-	-	-	-
CTABEND	-	-	-	-	-	-
CTABEXISTS	-	-	-	-	-	-

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
CTABFNO	-	-	-	-	-	-
CTABFPOL	-	-	-	-	-	-
CTABFSEG	-	-	-	-	-	-
CTABID	-	-	-	-	-	-
CTABINV	-	-	-	-	-	-
CTABISLOCK	-	-	-	-	-	-
CTABLOCK	-	-	-	-	-	-
CTABMEMTYP	-	-	-	-	-	-
CTABMPOL	-	-	-	-	-	-
CTABMSEG	-	-	-	-	-	-
CTABNO	-	-	-	-	-	-
CTABNOMEM	-	-	-	-	-	-
CTABPERIOD	-	-	-	-	-	-
CTABPOL	-	-	-	-	-	-
CTABPOLID	-	-	-	-	-	-
CTABSEG	-	-	-	-	-	-
CTABSEGID	-	-	-	-	-	-
CTABSEV	-	-	-	-	-	-
CTABSSV	-	-	-	-	-	-
CTABTEP	-	-	-	-	-	-
CTABTEV	-	-	-	-	-	-
CTABTMAX	-	-	-	-	-	-
CTABTMIN	-	-	-	-	-	-
CTABTSP	-	-	-	-	-	-
CTABTSV	-	-	-	-	-	-
CTABUNLOCK	-	-	-	-	-	-
CTOL	-	○	-	○	-	○
CTRANS	●	●	●	●	●	●
CUT2D	●	●	●	●	●	●
CUT2DF	●	●	●	●	●	●
CUT3DC	-	-	-	-	-	-
CUT3DCC	-	-	-	-	-	-
CUT3DCCD	-	-	-	-	-	-
CUT3DF	-	-	-	-	-	-
CUT3DFF	-	-	-	-	-	-
CUT3DFS	-	-	-	-	-	-
CUTCONOF	●	●	●	●	●	●
CUTCONON	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
CUTMOD	●	●	●	●	●	●
CYCLE...	●	●	●	●	●	●
D	●	●	●	●	●	●
D0	●	●	●	●	●	●
DAC	●	●	●	●	●	●
DC	●	●	●	●	●	●
DEF	●	●	●	●	●	●
DEFINE	●	●	●	●	●	●
DEFAULT	●	●	●	●	●	●
DELAYFSTON	●	●	●	●	●	●
DELAYFSTOF	●	●	●	●	●	●
DELDL	●	●	●	●	●	●
DELDTG	●	●	●	●	●	●
DELETE	●	●	●	●	●	●
DELMLOWNER	●	●	●	●	●	●
DELMLRES	●	●	●	●	●	●
DELMT	●	●	●	●	●	●
DELOBJ	-	-	-	-	-	-
DELT	●	●	●	●	●	●
DELTC	●	●	●	●	●	●
DELTOOLENV	●	●	●	●	●	●
DIACYCOFA	●	●	●	●	●	●
DIAM90	●	●	●	●	●	●
DIAM90A	●	●	●	●	●	●
DIAMCHAN	●	●	●	●	●	●
DIAMCHANA	●	●	●	●	●	●
DIAMCYCOF	●	●	●	●	●	●
DIAMOF	●	●	●	●	●	●
DIAMOFA	●	●	●	●	●	●
DIAMON	●	●	●	●	●	●
DIAMONA	●	●	●	●	●	●
DIC	●	●	●	●	●	●
DILF	●	●	●	●	●	●
DISABLE	●	●	●	●	●	●
DISC	●	●	●	●	●	●
DISCL	●	●	●	●	●	●
DISPLOF	●	●	●	●	●	●
DISPLON	●	●	●	●	●	●
DISPR	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
DISR	●	●	●	●	●	●
DISRP	●	●	●	●	●	●
DITE	●	●	●	●	●	●
DITS	●	●	●	●	●	●
DIV	●	●	●	●	●	●
DL	-	-	-	-	-	-
DO	●	●	●	●	●	●
DRFOF	●	●	●	●	●	●
DRIVE	●	●	●	●	●	●
DRIVEA	●	●	●	●	●	●
DYNFINISH	●	●	●	●	●	●
DYNNORM	●	●	●	●	●	●
DYNPOS	●	●	●	●	●	●
DYNROUGH	●	●	●	●	●	●
DYNSEMIFIN	●	●	●	●	●	●
DZERO	●	●	●	●	●	●
EAUTO	-	○	-	○	-	○
EGDEF	-	-	-	-	-	-
EGDEL	-	-	-	-	-	-
EGOFC	-	-	-	-	-	-
EGOFS	-	-	-	-	-	-
EGON	-	-	-	-	-	-
EGONSYN	-	-	-	-	-	-
EGONSYNE	-	-	-	-	-	-
ELSE	●	●	●	●	●	●
ENABLE	●	●	●	●	●	●
ENAT	-	○	-	○	-	○
ENDFOR	●	●	●	●	●	●
ENDIF	●	●	●	●	●	●
ENDLABEL	●	●	●	●	●	●
ENDLOOP	●	●	●	●	●	●
ENDPROC	●	●	●	●	●	●
ENDWHILE	●	●	●	●	●	●
ESRR	●	●	●	●	●	●
ESRS	●	●	●	●	●	●
ETAN	-	○	-	○	-	○
EVERY	●	●	●	●	●	●
EX	●	●	●	●	●	●
EXECSTRING	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
EXECTAB	●	●	●	●	●	●
EXECUTE	●	●	●	●	●	●
EXP	●	●	●	●	●	●
EXTCALL	●	●	●	●	●	●
EXTCLOSE	●	●	●	●	●	●
EXTERN	●	●	●	●	●	●
EXTOPEN	●	●	●	●	●	●
F	●	●	●	●	●	●
FA	●	●	●	●	●	●
FAD	●	●	●	●	●	●
FALSE	●	●	●	●	●	●
FB	●	●	●	●	●	●
FCTDEF	-	-	-	-	-	-
FCUB	●	●	●	●	●	●
FD	●	●	●	●	●	●
FDA	●	●	●	●	●	●
FENDNORM	●	●	●	●	●	●
FFWOF	●	●	●	●	●	●
FFWON	●	●	●	●	●	●
FGREF	●	●	●	●	●	●
FGROUP	●	●	●	●	●	●
FI	●	●	●	●	●	●
FIFOCTRL	●	●	●	●	●	●
FILEDATE	●	●	●	●	●	●
FILEINFO	●	●	●	●	●	●
FILESIZE	●	●	●	●	●	●
FILESTAT	●	●	●	●	●	●
FILETIME	●	●	●	●	●	●
FINEA	●	●	●	●	●	●
FL	●	●	●	●	●	●
FLIN	●	●	●	●	●	●
FMA	-	-	-	-	-	-
FNORM	●	●	●	●	●	●
FOCOF	○	-	○	-	○	-
FOCON	○	-	○	-	○	-
FOR	●	●	●	●	●	●
FP	●	●	●	●	●	●
FPO	-	-	-	-	-	-
FPR	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
FPRAOF	●	●	●	●	●	●
FPRAON	●	●	●	●	●	●
FRAME	●	●	●	●	●	●
FRC	●	●	●	●	●	●
FRCM	●	●	●	●	●	●
FROM	●	●	●	●	●	●
FTOC	●	●	●	●	●	●
FTOCOF	●	●	●	●	●	●
FTOCON	●	●	●	●	●	●
FXS	●	●	●	●	●	●
FXST	●	●	●	●	●	●
FXSW	●	●	●	●	●	●
FZ	●	●	●	●	●	●
G0	●	●	●	●	●	●
G1	●	●	●	●	●	●
G2	●	●	●	●	●	●
G3	●	●	●	●	●	●
G4	●	●	●	●	●	●
G5	●	●	●	●	●	●
G7	●	●	●	●	●	●
G9	●	●	●	●	●	●
G17	●	●	●	●	●	●
G18	●	●	●	●	●	●
G19	●	●	●	●	●	●
G25	●	●	●	●	●	●
G26	●	●	●	●	●	●
G33	●	●	●	●	●	●
G34	●	●	●	●	●	●
G35	●	●	●	●	●	●
G40	●	●	●	●	●	●
G41	●	●	●	●	●	●
G42	●	●	●	●	●	●
G53	●	●	●	●	●	●
G54	●	●	●	●	●	●
G55	●	●	●	●	●	●
G56	●	●	●	●	●	●
G57	●	●	●	●	●	●
G58	●	●	●	●	●	●
G59	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
G60	●	●	●	●	●	●
G62	●	●	●	●	●	●
G63	●	●	●	●	●	●
G64	●	●	●	●	●	●
G70	●	●	●	●	●	●
G71	●	●	●	●	●	●
G74	●	●	●	●	●	●
G75	●	●	●	●	●	●
G90	●	●	●	●	●	●
G91	●	●	●	●	●	●
G93	●	●	●	●	●	●
G94	●	●	●	●	●	●
G95	●	●	●	●	●	●
G96	●	●	●	●	●	●
G97	●	●	●	●	●	●
G110	●	●	●	●	●	●
G111	●	●	●	●	●	●
G112	●	●	●	●	●	●
G140	●	●	●	●	●	●
G141	●	●	●	●	●	●
G142	●	●	●	●	●	●
G143	●	●	●	●	●	●
G147	●	●	●	●	●	●
G148	●	●	●	●	●	●
G153	●	●	●	●	●	●
G247	●	●	●	●	●	●
G248	●	●	●	●	●	●
G290	●	●	●	●	●	●
G291	●	●	●	●	●	●
G331	●	●	●	●	●	●
G332	●	●	●	●	●	●
G340	●	●	●	●	●	●
G341	●	●	●	●	●	●
G347	●	●	●	●	●	●
G348	●	●	●	●	●	●
G450	●	●	●	●	●	●
G451	●	●	●	●	●	●
G460	●	●	●	●	●	●
G461	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
G462	●	●	●	●	●	●
G500	●	●	●	●	●	●
G505 ... G599	●	●	●	●	●	●
G601	●	●	●	●	●	●
G602	●	●	●	●	●	●
G603	●	●	●	●	●	●
G621	●	●	●	●	●	●
G641	●	●	●	●	●	●
G642	●	●	●	●	●	●
G643	●	●	●	●	●	●
G644	●	●	●	●	●	●
G645	●	●	●	●	●	●
G700	●	●	●	●	●	●
G710	●	●	●	●	●	●
G810 ... G819	-	-	-	-	-	-
G820 ... G829	-	-	-	-	-	-
G931	●	●	●	●	●	●
G942	●	●	●	●	●	●
G952	●	●	●	●	●	●
G961	●	●	●	●	●	●
G962	●	●	●	●	●	●
G971	●	●	●	●	●	●
G972	●	●	●	●	●	●
G973	●	●	●	●	●	●
GEOAX	●	●	●	●	●	●
GET	●	●	●	●	●	●
GETACTT	●	●	●	●	●	●
GETACTTD	●	●	●	●	●	●
GETD	●	●	●	●	●	●
GETDNO	●	●	●	●	●	●
GETEXET	●	●	●	●	●	●
GETFREELOC	●	●	●	●	●	●
GETSELT	●	●	●	●	●	●
GETT	●	●	●	●	●	●
GETTCOR	●	●	●	●	●	●
GETTENV	●	●	●	●	●	●
GETVARAP	●	●	●	●	●	●
GETVARDFT	●	●	●	●	●	●
GETVARLIM	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
GETVARPHU	●	●	●	●	●	●
GETVARTYP	●	●	●	●	●	●
GOTO	●	●	●	●	●	●
GOTOB	●	●	●	●	●	●
GOTOC	●	●	●	●	●	●
GOTOF	●	●	●	●	●	●
GOTOS	●	●	●	●	●	●
GP	●	●	●	●	●	●
GWPSOF	●	●	●	●	●	●
GWPSON	●	●	●	●	●	●
H...	●	●	●	●	●	●
HOLES1	●	●	●	●	●	●
HOLES2	●	●	●	●	●	●
I	●	●	●	●	●	●
I1	●	●	●	●	●	●
IC	●	●	●	●	●	●
ICYCOF	●	●	●	●	●	●
ICYCON	●	●	●	●	●	●
ID	●	●	●	●	●	●
IDS	●	●	●	●	●	●
IF	●	●	●	●	●	●
INDEX	●	●	●	●	●	●
INIPO	●	●	●	●	●	●
INIRE	●	●	●	●	●	●
INICF	●	●	●	●	●	●
INIT	-	-	-	-	-	-
INITIAL	●	●	●	●	●	●
INT	●	●	●	●	●	●
INTERSEC	●	●	●	●	●	●
INTTOAX	●	●	●	●	●	●
INVCCW	-	-	-	-	-	-
INVCW	-	-	-	-	-	-
INVFRAME	●	●	●	●	●	●
IP	●	●	●	●	●	●
IPOBRKA	●	●	●	●	●	●
IPOENDA	●	●	●	●	●	●
IPTRLOCK	●	●	●	●	●	●
IPTRUNLOCK	●	●	●	●	●	●
ISAXIS	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
ISD	-	-	-	-	-	-
ISFILE	●	●	●	●	●	●
ISNUMBER	●	●	●	●	●	●
ISOCALL	●	●	●	●	●	●
ISVAR	●	●	●	●	●	●
J	●	●	●	●	●	●
J1	●	●	●	●	●	●
JERKA	●	●	●	●	●	●
JERKLIM	●	●	●	●	●	●
JERKLIMA	●	●	●	●	●	●
K	●	●	●	●	●	●
K1	●	●	●	●	●	●
KONT	●	●	●	●	●	●
KONTC	●	●	●	●	●	●
KONTT	●	●	●	●	●	●
L	●	●	●	●	●	●
LEAD Tool orientation Orientation polynomial	 - -	 - -	 - -	 - -	 - -	 - -
LEADOF	-	-	-	-	-	-
LEADON	-	-	-	-	-	-
LENTOAX	●	●	●	●	●	●
LFOF	●	●	●	●	●	●
LFON	●	●	●	●	●	●
LFPOS	●	●	●	●	●	●
LFTXT	●	●	●	●	●	●
LFWP	●	●	●	●	●	●
LIFTFAST	●	●	●	●	●	●
LIMS	●	●	●	●	●	●
LLI	●	●	●	●	●	●
LN	●	●	●	●	●	●
LOCK	●	●	●	●	●	●
LONGHOLE	-	-	-	-	-	-
LOOP	●	●	●	●	●	●
M0	●	●	●	●	●	●
M1	●	●	●	●	●	●
M2	●	●	●	●	●	●
M3	●	●	●	●	●	●
M4	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
M5	●	●	●	●	●	●
M6	●	●	●	●	●	●
M17	●	●	●	●	●	●
M19	●	●	●	●	●	●
M30	●	●	●	●	●	●
M40	●	●	●	●	●	●
M41 ... M45	●	●	●	●	●	●
M70	●	●	●	●	●	●
MASLDEF	●	●	●	●	●	●
MASLDEL	●	●	●	●	●	●
MASLOF	●	●	●	●	●	●
MASLOFS	●	●	●	●	●	●
MASLON	●	●	●	●	●	●
MATCH	●	●	●	●	●	●
MAXVAL	●	●	●	●	●	●
MCALL	●	●	●	●	●	●
MEAC	-	-	-	-	-	-
MEAFRAME	●	●	●	●	●	●
MEAS	●	●	●	●	●	●
MEASA	-	-	-	-	-	-
MEASURE	●	●	●	●	●	●
MEAW	●	●	●	●	●	●
MEAWA	-	-	-	-	-	-
MI	●	●	●	●	●	●
MINDEX	●	●	●	●	●	●
MINVAL	●	●	●	●	●	●
MIRROR	●	●	●	●	●	●
MMC	●	●	●	●	●	●
MOD	●	●	●	●	●	●
MODAXVAL	●	●	●	●	●	●
MOV	●	●	●	●	●	●
MOVT	●	●	●	●	●	●
MSG	●	●	●	●	●	●
MVTOOL	●	●	●	●	●	●
N	●	●	●	●	●	●
NAMETOINT	-	-	-	-	-	-
NCK	●	●	●	●	●	●
NEWCONF	●	●	●	●	●	●
NEWMT	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
NEWT	●	●	●	●	●	●
NORM	●	●	●	●	●	●
NOT	●	●	●	●	●	●
NPROT	●	●	●	●	●	●
NPROTDEF	●	●	●	●	●	●
NUMBER	●	●	●	●	●	●
OEMIPO1	-	-	-	-	-	-
OEMIPO2	-	-	-	-	-	-
OF	●	●	●	●	●	●
OFFN	●	●	●	●	●	●
OMA1	-	-	-	-	-	-
OMA2	-	-	-	-	-	-
OMA3	-	-	-	-	-	-
OMA4	-	-	-	-	-	-
OMA5	-	-	-	-	-	-
OR	●	●	●	●	●	●
ORIAXES	-	-	-	-	-	-
ORIAXPOS	-	-	-	-	-	-
ORIC	-	-	-	-	-	-
ORICONCCW	-	-	-	-	-	-
ORICONCW	-	-	-	-	-	-
ORICONIO	-	-	-	-	-	-
ORICONTO	-	-	-	-	-	-
ORICURVE	-	-	-	-	-	-
ORID	-	-	-	-	-	-
ORIEULER	-	-	-	-	-	-
ORIMKS	-	-	-	-	-	-
ORIPATH	-	-	-	-	-	-
ORIPATHS	-	-	-	-	-	-
ORIPLANE	-	-	-	-	-	-
ORIRESET	-	-	-	-	-	-
ORIROTA	-	-	-	-	-	-
ORIROTC	-	-	-	-	-	-
ORIROTR	-	-	-	-	-	-
ORIROTT	-	-	-	-	-	-
ORIRPY	-	-	-	-	-	-
ORIRPY2	-	-	-	-	-	-
ORIS	-	-	-	-	-	-
ORISOF	-	-	-	-	-	-

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
ORISON	-	-	-	-	-	-
ORIVECT	-	-	-	-	-	-
ORIVIRT1	-	-	-	-	-	-
ORIVIRT2	-	-	-	-	-	-
ORIWKS	-	-	-	-	-	-
OS	-	-	-	-	-	-
OSB	-	-	-	-	-	-
OSC	-	-	-	-	-	-
OSCILL	-	-	-	-	-	-
OSCTRL	-	-	-	-	-	-
OSD	-	-	-	-	-	-
OSE	-	-	-	-	-	-
OSNSC	-	-	-	-	-	-
OSOF	-	-	-	-	-	-
OSP1	-	-	-	-	-	-
OSP2	-	-	-	-	-	-
OSS	-	-	-	-	-	-
OSSE	-	-	-	-	-	-
OST	-	-	-	-	-	-
OST1	-	-	-	-	-	-
OST2	-	-	-	-	-	-
OTOL	-	●	-	●	-	●
OVR	●	●	●	●	●	●
OVRA	●	●	●	●	●	●
OVRRAP	●	●	●	●	●	●
P	●	●	●	●	●	●
PAROT	●	●	●	●	●	●
PAROTOF	●	●	●	●	●	●
PCALL	●	●	●	●	●	●
PDELAYOF	-	-	-	-	-	-
PDELAYON	-	-	-	-	-	-
PHI	-	-	-	-	-	-
PHU	●	●	●	●	●	●
PL -	- -	○ -	- -	○ -	- -	○ -
PM	●	●	●	●	●	●
PO	-	-	-	-	-	-
POCKET3	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
POCKET4	●	●	●	●	●	●
POLF	●	●	●	●	●	●
POLFA	●	●	●	●	●	●
POLFMASK	●	●	●	●	●	●
POLFMLIN	●	●	●	●	●	●
POLY	-	-	-	-	-	-
POLYPATH	-	-	-	-	-	-
PON	-	-	-	-	-	-
PONS	-	-	-	-	-	-
POS	●	●	●	●	●	●
POSA	●	●	●	●	●	●
POSM	●	●	●	●	●	●
POSMT	●	●	●	●	●	●
POSP	●	●	●	●	●	●
POSRANGE	●	●	●	●	●	●
POT	●	●	●	●	●	●
PR	●	●	●	●	●	●
PREPRO	●	●	●	●	●	●
PRESETON	●	●	●	●	●	●
PRIO	●	●	●	●	●	●
PRLOC	●	●	●	●	●	●
PROC	●	●	●	●	●	●
PROTA	-	-	-	-	-	-
PROTD	-	-	-	-	-	-
PROTS	-	-	-	-	-	-
PSI	-	-	-	-	-	-
PTP	●	●	●	●	●	●
PTPG0	●	●	●	●	●	●
PUNCHACC	-	-	-	-	-	-
PUTFTOC	●	●	●	●	●	●
PUTFTOCF	●	●	●	●	●	●
PW	-	○	-	○	-	○
QU	●	●	●	●	●	●
R...	●	●	●	●	●	●
RAC	●	●	●	●	●	●
RDISABLE	●	●	●	●	●	●
READ	●	●	●	●	●	●
REAL	●	●	●	●	●	●
REDEF	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
RELEASE	●	●	●	●	●	●
REP	●	●	●	●	●	●
REPEAT	●	●	●	●	●	●
REPEATB	●	●	●	●	●	●
REPOSA	●	●	●	●	●	●
REPOSH	●	●	●	●	●	●
REPOSHA	●	●	●	●	●	●
REPOSL	●	●	●	●	●	●
REPOSQ	●	●	●	●	●	●
REPOSQA	●	●	●	●	●	●
RESET	●	●	●	●	●	●
RESETMON	●	●	●	●	●	●
RET	●	●	●	●	●	●
RIC	●	●	●	●	●	●
RINDEX	●	●	●	●	●	●
RMB	●	●	●	●	●	●
RME	●	●	●	●	●	●
RMI	●	●	●	●	●	●
RMN	●	●	●	●	●	●
RND	●	●	●	●	●	●
RNDM	●	●	●	●	●	●
ROT	●	●	●	●	●	●
ROTS	●	●	●	●	●	●
ROUND	●	●	●	●	●	●
ROUNDUP	●	●	●	●	●	●
RP	●	●	●	●	●	●
RPL	●	●	●	●	●	●
RT	●	●	●	●	●	●
RTLIOF	●	●	●	●	●	●
RTLION	●	●	●	●	●	●
S	●	●	●	●	●	●
SAVE	●	●	●	●	●	●
SBLOF	●	●	●	●	●	●
SBLON	●	●	●	●	●	●
SC	●	●	●	●	●	●
SCALE	●	●	●	●	●	●
SCC	●	●	●	●	●	●
SCPARA	●	●	●	●	●	●
SD	-	○	-	○	-	○

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
SET	●	●	●	●	●	●
SETAL	●	●	●	●	●	●
SETDNO	●	●	●	●	●	●
SETINT	●	●	●	●	●	●
SETM	-	-	-	-	-	-
SETMS	●	●	●	●	●	●
SETMS(n)	●	●	●	●	●	●
SETMTH	●	●	●	●	●	●
SETPIECE	●	●	●	●	●	●
SETTA	●	●	●	●	●	●
SETTCOR	●	●	●	●	●	●
SETTIA	●	●	●	●	●	●
SF	●	●	●	●	●	●
SIN	●	●	●	●	●	●
SIRELAY	-	-	-	-	-	-
SIRELIN	-	-	-	-	-	-
SIRELOUT	-	-	-	-	-	-
SIRELTIME	-	-	-	-	-	-
SLOT1	●	●	●	●	●	●
SLOT2	●	●	●	●	●	●
SOFT	●	●	●	●	●	●
SOFTA	●	●	●	●	●	●
SON	-	-	-	-	-	-
SONS	-	-	-	-	-	-
SPATH	●	●	●	●	●	●
SPCOF	●	●	●	●	●	●
SPCON	●	●	●	●	●	●
SPI	●	●	●	●	●	●
SPIF1	-	-	-	-	-	-
SPIF2	-	-	-	-	-	-
SPLINEPATH	-	○	-	○	-	○
SPN	-	-	-	-	-	-
SPOF	-	-	-	-	-	-
SPOS	●	●	●	●	●	●
SPOSA	●	●	●	●	●	●
SPP	-	-	-	-	-	-
SPRINT	●	●	●	●	●	●
SQRT	●	●	●	●	●	●
SR	-	-	-	-	-	-

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
SRA	-	-	-	-	-	-
ST	-	-	-	-	-	-
STA	-	-	-	-	-	-
START	-	-	-	-	-	-
STARTFIFO	●	●	●	●	●	●
STAT	●	●	●	●	●	●
STOLF	-	-	-	-	-	-
STOPFIFO	●	●	●	●	●	●
STOPRE	●	●	●	●	●	●
STOPREOF	●	●	●	●	●	●
STRING	●	●	●	●	●	●
STRINGFELD	●	●	●	●	●	●
STRINGIS	●	●	●	●	●	●
STRINGVAR	-	-	-	-	-	-
STRLEN	●	●	●	●	●	●
SUBSTR	●	●	●	●	●	●
SUPA	●	●	●	●	●	●
SVC	●	●	●	●	●	●
SYNFCT	●	●	●	●	●	●
SYNR	●	●	●	●	●	●
SYNRW	●	●	●	●	●	●
SYNW	●	●	●	●	●	●
T	●	●	●	●	●	●
TAN	●	●	●	●	●	●
TANG	-	-	-	-	-	-
TANGDEL	-	-	-	-	-	-
TANGOF	-	-	-	-	-	-
TANGON	-	-	-	-	-	-
TCA (828D: _TCA)	●	●	●	●	●	●
TCARR	-	●	-	●	-	●
TCI	●	●	●	●	●	●
TCOABS	-	●	-	●	-	●
TCOFR	-	●	-	●	-	●
TCOFRX	-	●	-	●	-	●
TCOFRY	-	●	-	●	-	●
TCOFRZ	-	●	-	●	-	●
THETA	-	-	-	-	-	-
TILT	-	-	-	-	-	-

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
TLIFT	-	-	-	-	-	-
TML	●	●	●	●	●	●
TMOF	●	●	●	●	●	●
TMON	●	●	●	●	●	●
TO	●	●	●	●	●	●
TOFF	●	●	●	●	●	●
TOFFL	●	●	●	●	●	●
TOFFOF	●	●	●	●	●	●
TOFFON	●	●	●	●	●	●
TOFFR	●	●	●	●	●	●
TOFRAME	●	●	●	●	●	●
TOFRAMEX	●	●	●	●	●	●
TOFRAMEY	●	●	●	●	●	●
TOFRAMEZ	●	●	●	●	●	●
TOLOWER	●	●	●	●	●	●
TOOLENV	●	●	●	●	●	●
TOOLGNT	●	●	●	●	●	●
TOOLGT	●	●	●	●	●	●
TOROT	●	●	●	●	●	●
TOROTOF	●	●	●	●	●	●
TOROTX	●	●	●	●	●	●
TOROTY	●	●	●	●	●	●
TOROTZ	●	●	●	●	●	●
TOUPPER	●	●	●	●	●	●
TOWBCS	-	●	-	●	-	●
TOWKCS	-	●	-	●	-	●
TOWMCS	-	●	-	●	-	●
TOWSTD	-	●	-	●	-	●
TOWTCS	-	●	-	●	-	●
TOWWCS	-	●	-	●	-	●
TR	●	●	●	●	●	●
TRAANG	-	-	-	-	○	-
TRACON	-	-	-	-	○	-
TRACYL	○	○	○	○	○	○
TRAFOOF	●	●	●	●	●	●
TRAILOF	●	●	●	●	●	●
TRAILON	●	●	●	●	●	●
TRANS	●	●	●	●	●	●
TRANSMIT	○	○	○	○	○	○

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
TRAORI	-	●	-	●	-	●
TRUE	●	●	●	●	●	●
TRUNC	●	●	●	●	●	●
TU	●	●	●	●	●	●
TURN	●	●	●	●	●	●
ULI	●	●	●	●	●	●
UNLOCK	●	●	●	●	●	●
UNTIL	●	●	●	●	●	●
UPATH	●	●	●	●	●	●
VAR	●	●	●	●	●	●
VELOLIM	●	●	●	●	●	●
VELOLIMA	●	●	●	●	●	●
WAITC	-	-	-	-	○	-
WAITE	-	-	-	-	-	-
WAITENC	-	-	-	-	-	-
WAITM	-	-	-	-	-	-
WAITMC	-	-	-	-	-	-
WAITP	●	●	●	●	●	●
WAITS	●	●	●	●	●	●
WALCS0	●	●	●	●	●	●
WALCS1	●	●	●	●	●	●
WALCS2	●	●	●	●	●	●
WALCS3	●	●	●	●	●	●
WALCS4	●	●	●	●	●	●
WALCS5	●	●	●	●	●	●
WALCS6	●	●	●	●	●	●
WALCS7	●	●	●	●	●	●
WALCS8	●	●	●	●	●	●
WALCS9	●	●	●	●	●	●
WALCS10	●	●	●	●	●	●
WALIMOF	●	●	●	●	●	●
WALIMON	●	●	●	●	●	●
WHEN	●	●	●	●	●	●
WHENEVER	●	●	●	●	●	●
WHILE	●	●	●	●	●	●
WRITE	●	●	●	●	●	●
WRTPR	●	●	●	●	●	●
X	●	●	●	●	●	●
XOR	●	●	●	●	●	●

Operation	828D control version					
● Standard	PPU240.2 / 241.2		PPU260.2 / 261.2		PPU280.2 / 281.2	
○ Option - not available	BASIC T	BASIC M	Turning	Milling	Turning	Milling
Y	●	●	●	●	●	●
Z	●	●	●	●	●	●

19.3 Currently set language in the HMI

The table below lists all of the languages available at the user interface.

The currently set language can be queried in the part program and in the synchronized actions using the following system variable:

$AN_LANGUAGE_ON_HMI = <value>

<value>	Language	Language code
1	German (Germany)	GER
2	French	FRA
3	English (Great Britain)	ENG
4	Spanish	ESP
6	Italian	ITA
7	Dutch	NLD
8	Simplified Chinese	CHS
9	Swedish	SVE
18	Hungarian	HUN
19	Finnish	FIN
28	Czech	CSY
50	Portuguese (Brazil)	PTB
53	Polish	PLK
55	Danish	DAN
57	Russian	RUS
68	Slovakian	SKY
72	Rumanian	ROM
80	Traditional Chinese	CHT
85	Korean	KOR
87	Japanese	JPN
89	Turkish	TRK

Note

$AN_LANGUAGE_ON_HMI is updated:

- after the system boots.
- after NCK and/or PLC reset.
- after switching over to another NCK within the scope of M2N.
- after changing over the language on the HMI.

Appendix A

A.1 List of abbreviations

A	
AC	Adaptive Control
ADI4	(Analog drive interface for 4 axes)
ALM	Active Line Module
ARM	Rotating induction motor
AS	PLC
ASCII	American Standard Code for Information Interchange
ASIC	Application-Specific Integrated Circuit: User switching circuit
ASUB	Asynchronous subprogram
AuxF	Auxiliary Function
AUXFU	Auxiliary Function

B	
BA	Mode
BAG	Mode group
BCD	Binary Coded Decimals: Decimal numbers encoded in binary code
BCS	Basic Coordinate System
BERO	Proximity limit switch with feedback oscillator
BI	Binector Input
BICO	Binector Connector
BIN	BINary files
BIOS	Basic Input Output System
BO	Binector Output

C	
CAD	Computer-Aided Design
CAM	Computer-Aided Manufacturing
CC	Compile Cycle
CF Card	Compact Flash Card
CI	Connector Input
CNC	Computerized Numerical Control
CO	Connector Output
CoL	Certificate of License

C	
COM	Communication
CP	Communication Processor
CPA	Compiler Projecting Data: Configuring data of the compiler
CPU	Central Processing Unit
CR	Carriage Return
CRC	Cutter Radius Compensation
CRT	Cathode Ray Tube picture tube
CSB	Central Service Board: PLC module
CTS	Clear To Send: Ready to send signal for serial data interfaces
CU	Control Unit
CUTCOM	Cutter radius Compensation: Tool radius compensation

D	
DAC	Digital-to-Analog Converter
DB	Data Block (PLC)
DBB	Data Block Byte (PLC)
DBD	Data Block Double word (PLC)
DBW	Data Block Word (PLC)
DBX	Data block bit (PLC)
DDE	Dynamic Data Exchange
DIN	Deutsche Industrie Norm [German Industry Standard]
DIO	Data Input/Output: Data transfer display
DIR	Directory
DLL	Dynamic Link Library
DO	Drive Object
DPM	Dual Port Memory
DPR	Dual Port RAM
DRAM	Dynamic memory (non-buffered)
DRF	Differential Resolver Function (handwheel)
DRIVE-CLiQ	Drive Component Link with IQ
DRY	Dry Run
DSB	Decoding Single Block
DSC	Dynamic Servo Control / Dynamic Stiffness Control
DW	Data Word
DWORD	Double Word (currently 32 bits)

E	
EFP	Compact I/O module (PLC I/O module)
EMC	ElectroMagnetic Compatibility

E	
EN	European standard
ENC	Encoder: Actual value encoder
EnDat	Encoder interface
EPROM	Erasable Programmable Read Only Memory: Erasable, electrically programmable read-only memory
ePS Network Services	Services for Internet-based remote machine maintenance
EQN	Designation for an absolute encoder with 2048 sine signals per revolution
ES	Engineering System
ESD	Electrostatic Sensitive Devices
ESR	Extended Stop and Retract
ETC	ETC key ">"; softkey bar extension in the same menu

F	
FB	Function Block (PLC)
FBD	Function Block Diagram (PLC programming method)
FC	Function Call: Function Block (PLC)
FDD	Feed Drive
FEPROM	Flash EPROM: Read and write memory
FIFO	First In First Out: Memory that works without address specification and whose data is read in the same order in which they was stored
FIPO	Fine interpolator
FPU	Floating Point Unit:
FST	Feed Stop
FW	Firmware

G	
GC	Global Control (PROFIBUS: Broadcast telegram)
GEO	Geometry, e.g. geometry axis
GIA	Gear Interpolation dAta
GND	Signal Ground
GP	Basic program (PLC)
GS	Gear Stage
GSD	Device master file for describing a PROFIBUS slave
GSDML	Generic Station Description Markup Language: XML-based description language for creating a GSD file
GUD	Global User Data
GWPS	Grinding Wheel Peripheral Speed

H	
HEX	Abbreviation for hexadecimal number
HLA	Hydraulic linear drive
HMI	Human Machine Interface: SINUMERIK user interface
HW	Hardware

I	
I	Input
I/O	Input/Output
IBN	Commissioning
ICA	Interpolatory compensation
IM	Interface Module Interconnection module
IMR	Interface Module Receive: Interface module for receiving data
IMS	Interface Module Send: Interface module for sending data
INC	Increment
INI	Initializing Data
IPO	Interpolator
IS	Interface Signal
ISA	Industry Standard Architecture
ISO	International Standardization Organization

J	
JOG	Jogging: Setup mode

K	
K_p	Proportional gain
$K_Ü$	Transformation ratio
K_V	Gain factor of control loop

L	
LAD	Ladder Diagram (PLC programming method)
LAI	Logic Machine Axis Image
LAN	Local Area Network
LCD	Liquid Crystal Display
LEC	Leadscrew Error Compensation
LED	Light Emitting Diode
LF	Line Feed

L	
LR	Position controller
LSB	Least Significant Bit
LUD	Local User Data

M	
MAC	Media Access Control
MAIN	Main program (OB1, PLC)
MB	Megabyte
MCI	Motion Control Interface
MCIS	Motion Control Information System
MCP	Machine Control Panel
MCP	Machine Control Panel
MCS	Machine Coordinate System
MD	Machine Data
MDA	Manual Data Automatic: Manual input
MLFB	Machine-readable product code
MM	Motor Module
MPF	Main Program File (NC)
MSD	Main Spindle Drive
MSGW	Message Word

N	
NC	Numerical Control
NCK	Numerical Control Kernel: NC kernel with block preparation, traversing range, etc.
NCU	Numerical Control Unit: NCK hardware unit
NRK	Name for the operating system of the NCK
NURBS	Non-Uniform Rational B-Spline
NX	Numerical Extension: Axis expansion board

O	
O	Output
OB	Organization block in the PLC
OEM	Original Equipment Manufacturer
OLP	Optical Link Plug: Fiber optic bus connector
OP	Operator Panel: Operating equipment
OPI	Operator Panel Interface
OPI	Operator Panel Interface: Interface for connection to the operator panel
OPT	Options
OSI	Open Systems Interconnection: Standard for computer communications

P	
PC	Personal Computer
PCIN	Name of the SW for data exchange with the controller
PCMCIA	Personal Computer Memory Card International Association: Plug-in memory card standardization
PCU	PC Unit: PC box (computer unit)
PG	Programming device
PII	Process Image Input
PIQ	Process Image Output
PIV	Parameter identification: Value (parameterizing part of a PPO)
PKE	Parameter identification: Part of a PIV
PLC	Programmable Logic Control: Adaptation control
PMS	Position Measuring System
PN	PROFINET
PNO	PROFIBUS user organization
PO	POWER ON
POS	Position/positioning
POSMO A	Positioning Motor Actuator: Positioning motor
POSMO CA	Positioning Motor Compact AC: Complete drive unit with integrated power and control module as well as positioning unit and program memory; AC infeed
POSMO CD	Positioning Motor Compact DC: Like CA but with DC infeed
POSMO SI	Positioning Motor Servo Integrated: Positioning motor, DC infeed
POU	Program Organization Unit
PPO	Parameter Process data Object: Cyclic data telegram for PROFIBUS DP transmission and "Variable speed drives" profile
PPU	Panel Processing Unit (central hardware for a panel-based CNC, e.g SINUMERIK 828D)
PROFIBUS	Process Field Bus: Serial data bus
PRT	Program Test
PSW	Program control word
PTP	Point-To-Point
PUD	Program global User Data
PZD	Process data: Process data part of a PPO

Q	
QEC	Quadrant Error Compensation

R	
RAM	Random Access Memory: Read/write memory
REF	REFerence point approach function
REPOS	REPOSition function

R	
RISC	Reduced Instruction Set Computer: Type of processor with small instruction set and ability to process instructions at high speed
ROV	Rapid Override: Input correction
RP	R Parameter, arithmetic parameter, predefined user variable
RPA	R Parameter Active: Memory area on the NCK for R parameter numbers
RPY	Roll Pitch Yaw: Rotation type of a coordinate system
RTCP	Real Time Control Protocol
RTLI	Rapid Traverse Linear Interpolation: Linear interpolation during rapid traverse motion
RTS	Request To Send: Control signal of serial data interfaces

S	
SA	Synchronized Action
SAR	Smooth Approach and Retraction
SBC	Safe Brake Control
SBL	Single Block
SBR	Subroutine (PLC)
SD	Setting Data
SDB	System Data Block
SEA	Setting Data Active: Identifier (file type) for setting data
SERUPRO	SEarch RUn by PROgram test
SFB	System Function Block
SFC	System Function Call
SGA	Safety-related output
SGE	Safety-related input
SH	Safe standstill
SIM	Single Inline Module
SK	Softkey
SKP	Skip: Function for skipping a part program block
SLM	Synchronous Linear Motor
SM	Stepper Motor
SMC	Sensor Module Cabinet Mounted
SME	Sensor Module Externally Mounted
SMI	Sensor Module Integrated
SPF	Sub Routine File: Subprogram (NC)
SR	Subprogram
SRAM	Static RAM (non-volatile)
SRM	Synchronous Rotary Motor
SSI	Serial Synchronous Interface
SSL	Block search
STL	Statement List
STW	Control word

S	
SW	Software
SYF	System Files
SYNACT	SYNchronized ACTion

T	
T	Tool
TB	Terminal Board (SINAMICS)
TC	Tool change
TCP	Tool Center Point: Tool tip
TCP/IP	Transport Control Protocol / Internet Protocol
TCU	Thin Client Unit
TEA	Testing Data Active: Identifier for machine data
TIA	Totally Integrated Automation
TLC	Tool Length Compensation
TM	Terminal Module (SINAMICS)
TM	Tool Management
TNRC	Tool Nose Radius Compensation
TO	Tool Offset
TOA	Tool Offset Active: Identifier (file type) for tool offsets
TRANSMIT	Transform Milling Into Turning: Coordination transformation for milling operations on a lathe
TRC	Tool Radius Compensation
TTL	Transistor-Transistor Logic (interface type)
TZ	Technology cycle

U	
UFR	User Frame: Zero Offset
UP	User Program
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus

V	
VDE	Verband Deutscher Elektrotechniker [Association of German Electrical Engineers]
VDI	Internal communication interface between NCK and PLC
VDI	Verein Deutscher Ingenieure [Association of German Engineers]
VI	Voltage Input
VO	Voltage Output

W	
WCS	Workpiece Coordinate System
WOP	Workshop-Oriented Programming
WPD	Workpiece Directory

X	
XML	Extensible Markup Language

Z	
ZO	Zero Offset
ZOA	Zero Offset Active: Identifier for zero offsets
ZSW	Status word (of drive)

A.2 Documentation overview

General Documentation

Sales brochure
– SINUMERIK 840D sl
– SINUMERIK 828D
– SINUMERIK 828D BASIC T

Catalog NC 62
SINUMERIK 840D sl
Type 1B

Catalog NC 82
SINUMERIK 828D
BASIC T/BASIC M
SINAMICS S120 Combi
Motors 1FK7 and 1PH8

Catalog PM 21
SIMOTION
SINAMICS S120
and motors for
production machines

Configuration Manual
EMC Design Guidelines

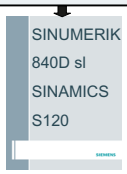
System Manual
Ctrl-Energy

User documentation

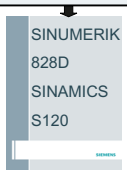
Operating Manual
– Universal
– Turning
– Milling

Programming Manual
– Fundamentals
– Job planning
– Measuring cycles

Programming Manual
– ISO turning
– ISO milling



Diagnostics Manual



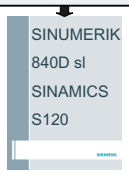
Diagnostics Manual

Manufacturer/service documentation

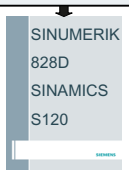
Manual
– NCU
– operator components and networking

Manual
Commissioning Manual
Service Manual

Commissioning Manual
– CNC: NCK, PLC, Drive
– -base software and operating software



List Manual
– Machine data
– Interface signals
– Variables



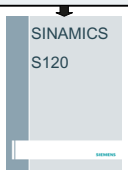
List Manual
– Machine data
– Interface signals
– Parameters
– Variables

System Manual
Guidelines for machine configuration

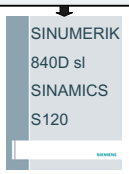
Manufacturer/service documentation

Function Manual
– Basic functions
– Extended functions
– Special functions
– Synchronized actions
– ISO dialects

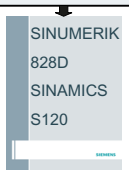
Function Manual
Tool management



Function Manual
Drive functions



Function Manual
Safety Integrated



Function Manual
Safety Integrated

Info / training

Training document
– Simple milling with ShopMill
– Simple turning with ShopTurn

Manuals
Tool and mold building

Electronic documentation

DOConCD

My Documentation Manager

Industry Mall

Glossary

Absolute dimensions

A destination for an axis motion is defined by a dimension that refers to the origin of the currently active coordinate system. See → Incremental dimension

Acceleration with jerk limitation

In order to optimize the acceleration response of the machine whilst simultaneously protecting the mechanical components, it is possible to switch over in the machining program between abrupt acceleration and continuous (jerk-free) acceleration.

Address

An address is the identifier for a certain operand or operand range, e.g. input, output, etc.

Alarms

All → messages and alarms are displayed on the operator panel in plain text with date and time and the corresponding symbol for the cancel criterion. Alarms and messages are displayed separately.

1. Alarms and messages in the part program:

   Alarms and messages can be displayed in plain text directly from the part program.

2. Alarms and messages from the PLC:

   Alarms and messages for the machine can be displayed in plain text from the PLC program. No additional function block packages are required for this purpose.

Archiving

Reading out of files and/or directories on an **external** memory device.

Asynchronous subprogram

Part program that can be started asynchronously to (independently of) the current program status using an interrupt signal (e.g. "Rapid NC input" signal).

Automatic

Operating mode of the controller (block sequence operation according to DIN): Operating mode for NC systems in which a → subprogram is selected and executed continuously.

Auxiliary functions

Auxiliary functions enable → part programs to transfer → parameters to the → PLC, which then trigger reactions defined by the machine manufacturer.

Axes

In accordance with their functional scope, the CNC axes are subdivided into:

- Axes: Interpolating path axes
- Auxiliary axes: Non-interpolating feed and positioning axes with an axis-specific feedrate. Auxiliary axes are not involved in actual machining, e.g. tool feeder, tool magazine.

Axis address

See → Axis name

Axis name

To ensure clear identification, all channel and → machine axes of the control system must be designated with unique names in the channel and control system. The → geometry axes are called X, Y, Z. The rotary axes rotating around the geometry axes → are called A, B, C.

Backlash compensation

Compensation for a mechanical machine backlash, e.g. backlash on reversal for ball screws. Backlash compensation can be entered separately for each axis.

Backup battery

The backup battery ensures that the → user program in the → CPU is stored so that it is safe from power failure and so that specified data areas and bit memory, timers and counters are stored retentively.

Basic axis

Axis whose setpoint or actual value position forms the basis of the calculation of a compensation value.

Basic Coordinate System

Cartesian coordinate system which is mapped by transformation onto the machine coordinate system.

The programmer uses axis names of the basic coordinate system in the → part program. The basic coordinate system exists parallel to the → machine coordinate system if no → transformation is active. The difference lies in the → axis names.

Baud rate

Rate of data transfer (bits/s).

Blank

Workpiece as it is before it is machined.

Block

"Block" is the term given to any files required for creating and processing programs.

Block search

For debugging purposes or following a program abort, the "Block search" function can be used to select any location in the part program at which the program is to be started or resumed.

Booting

Loading the system program after power ON.

C axis

Axis around which the tool spindle describes a controlled rotational and positioning motion.

C spline

The C spline is the most well-known and widely used spline. The transitions at the interpolation points are continuous, both tangentially and in terms of curvature. 3rd order polynomials are used.

Channel

A channel is characterized by the fact that it can process a → part program independently of other channels. A channel exclusively controls the axes and spindles assigned to it. Part program runs of different channels can be coordinated through → synchronization.

Circular interpolation

The → tool moves on a circle between specified points on the contour at a given feedrate, and the workpiece is thereby machined.

CNC

See → NC

COM

Component of the NC for the implementation and coordination of communication.

Compensation axis

Axis with a setpoint or actual value modified by the compensation value

Compensation table

Table containing interpolation points. It provides the compensation values of the compensation axis for selected positions on the basic axis.

Compensation value

Difference between the axis position measured by the encoder and the desired, programmed axis position.

Continuous-path mode

The objective of continuous-path mode is to avoid substantial deceleration of the → path axes at the part program block boundaries and to change to the next block at as close to the same path velocity as possible.

Contour

Contour of the → workpiece

Contour monitoring

The following error is monitored within a definable tolerance band as a measure of contour accuracy. An unacceptably high following error can cause the drive to become overloaded, for example. In such cases, an alarm is output and the axes are stopped.

Coordinate system

See → Machine coordinate system, → Workpiece coordinate system

CPU

Central processing unit, see → PLC

Curvature

The curvature k of a contour is the inverse of radius r of the nestling circle in a contour point (k = 1/r).

Cycles

Protected subprograms for execution of repetitive machining operations on the → workpiece.

Data block

1. Data unit of the → PLC that → HIGHSTEP programs can access.
2. Data unit of the → NC: Data modules contain data definitions for global user data. This data can be initialized directly when it is defined.

Data word

Two-byte data unit within a → data block.

Diagnostics

1. Operating area of the controller.
2. The controller has a self-diagnostics program as well as test functions for servicing purposes: status, alarm, and service displays

Dimensions specification, metric and inches

Position and pitch values can be programmed in inches in the machining program. Irrespective of the programmable dimensions (G70/G71), the controller is set to a basic system.

DRF

Differential Resolver Function: NC function which generates an incremental zero offset in Automatic mode in conjunction with an electronic handwheel.

Drive

The drive is the unit of the CNC that performs the speed and torque control based on the settings of the NC.

Dynamic feedforward control

Inaccuracies in the → contour due to following errors can be practically eliminated using dynamic, acceleration-dependent feedforward control. This results in excellent machining accuracy even at high → path velocities. Feedforward control can be selected and deselected on an axis-specific basis via the → part program.

Editor

The editor makes it possible to create, edit, extend, join, and import programs/texts/program blocks.

Exact stop

When an exact stop statement is programmed, the position specified in a block is approached exactly and, if necessary, very slowly. To reduce the approach time, → exact stop limits are defined for rapid traverse and feed.

Exact stop limit

When all path axes reach their exact stop limits, the controller responds as if it had reached its precise destination point. A block advance of the → part program occurs.

External zero offset

Zero offset specified by the → PLC.

Fast retraction from the contour

When an interrupt occurs, a motion can be initiated via the CNC machining program, enabling the tool to be quickly retracted from the workpiece contour that is currently being machined. The retraction angle and the distance retracted can also be parameterized. An interrupt routine can also be executed following the fast retraction.

Feed override

The programmed velocity is overriden by the current velocity setting made via the → machine control panel or from the → PLC (0 to 200%). The feedrate can also be corrected by a programmable percentage factor (1 to 200%) in the machining program.

Finished-part contour

Contour of the finished workpiece. See → Raw part.

Fixed machine point

Point that is uniquely defined by the machine tool, e.g. machine reference point.

Fixed-point approach

Machine tools can approach fixed points such as a tool change point, loading point, pallet change point, etc. in a defined way. The coordinates of these points are stored in the controller. The controller moves the relevant axes in → rapid traverse, whenever possible.

Frame

A frame is an arithmetic rule that transforms one Cartesian coordinate system into another Cartesian coordinate system. A frame contains the following components: → zero offset, → rotation, → scaling, → mirroring.

Geometry

Description of a → workpiece in the → workpiece coordinate system.

Geometry axis

The geometry axes form the 2 or 3-dimensional → workpiece coordinate system in which, in → part programs, the geometry of the workpiece is programmed.

Ground

Ground is taken as the total of all linked inactive parts of a device which will not become live with a dangerous contact voltage even in the event of a malfunction.

Helical interpolation

The helical interpolation function is ideal for machining internal and external threads using form milling cutters and for milling lubrication grooves.

The helix comprises two motions:

- Circular motion in one plane
- A linear motion perpendicular to this plane

High-level CNC language

The high-level language offers: → user-defined variables, → system variables, → macro techniques.

High-speed digital inputs/outputs

The digital inputs can be used for example to start fast CNC program routines (interrupt routines). High-speed, program-driven switching functions can be initiated via the digital CNC outputs

HIGHSTEP

Summary of programming options for → PLCs of the AS300/AS400 system.

HW Config

SIMATIC S7 tool for the configuration and parameterization of hardware components within an S7 project

Identifier

In accordance with DIN 66025, words are supplemented using identifiers (names) for variables (arithmetic variables, system variables, user variables), subprograms, key words, and words with multiple address letters. These supplements have the same meaning as the words with respect to block format. Identifiers must be unique. It is not permissible to use the same identifier for different objects.

Inch measuring system

Measuring system which defines distances in inches and fractions of inches.

Inclined surface machining

Drilling and milling operations on workpiece surfaces that do not lie in the coordinate planes of the machine can be performed easily using the function "inclined-surface machining".

Increment

Travel path length specification based on number of increments. The number of increments can be stored as → setting data or be selected by means of a suitably labeled key (i.e. 10, 100, 1000, 10000).

Incremental dimension

Also incremental dimension: A destination for axis traversal is defined by a distance to be covered and a direction referenced to a point already reached. See → Absolute dimension.

Intermediate blocks

Motions with selected → tool offset (G41/G42) may be interrupted by a limited number of intermediate blocks (blocks without axis motions in the offset plane), whereby the tool offset can still be correctly compensated for. The permissible number of intermediate blocks which the controller reads ahead can be set in system parameters.

Interpolator

Logic unit of the → NCK that defines intermediate values for the motions to be carried out in individual axes based on information on the end positions specified in the part program.

Interpolatory compensation

Interpolatory compensation is a tool that enables manufacturing-related leadscrew error and measuring system error compensations (SSFK, MSFK).

Interrupt routine

Interrupt routines are special → subprograms that can be started by events (external signals) in the machining process. A part program block which is currently being worked through is interrupted and the position of the axes at the point of interruption is automatically saved.

Inverse-time feedrate

The time required for the path of a block to be traversed can also be programmed for the axis motion instead of the feed velocity (G93).

JOG

Control operating mode (setup mode): In JOG mode, the machine can be set up. Individual axes and spindles can be traversed in JOG mode by means of the direction keys. Additional functions in JOG mode include: → Reference point approach, → Repos, and → Preset (set actual value).

Key switch

The key switch on the → machine control panel has four positions that are assigned functions by the operating system of the controller. The key switch has three different colored keys that can be removed in the specified positions.

Keywords

Words with specified notation that have a defined meaning in the programming language for → part programs.

KÜ

Transformation ratio

KV

Servo gain factor, a control variable in a control loop.

Leading axis

The leading axis is the → gantry axis that exists from the point of view of the operator and programmer and, thus, can be influenced like a standard NC axis.

Leadscrew error compensation

Compensation for the mechanical inaccuracies of a leadscrew participating in the feed. The controller uses stored deviation values for the compensation.

Limit speed

Maximum/minimum (spindle) speed: The maximum speed of a spindle can be limited by specifying machine data, the → PLC or → setting data.

Linear axis

In contrast to a rotary axis, a linear axis describes a straight line.

Linear interpolation

The tool travels along a straight line to the destination point while machining the workpiece.

Load memory

The load memory is the same as the → working memory for the CPU 314 of the → PLC.

Look Ahead

The **Look Ahead** function is used to achieve an optimal machining speed by looking ahead over an assignable number of traversing blocks.

Machine axes

Physically existent axes on the machine tool.

Machine control panel

An operator panel on a machine tool with operating elements such as keys, rotary switches, etc., and simple indicators such as LEDs. It is used to directly influence the machine tool via the PLC.

Machine coordinate system

A coordinate system, which is related to the axes of the machine tool.

Machine zero

Fixed point of the machine tool to which all (derived) measuring systems can be traced back.

Machining channel

A channel structure can be used to shorten idle times by means of parallel motion sequences, e.g. moving a loading gantry simultaneously with machining. Here, a CNC channel must be regarded as a separate CNC control system with decoding, block preparation and interpolation.

Macro techniques

Grouping of a set of statements under a single identifier. The identifier represents the set of consolidated statements in the program.

Main block

A block prefixed by ":" introductory block, containing all the parameters required to start execution of a -> part program.

Main program

The term "main program" has its origins during the time when part programs were split strictly into main and → subprograms. This strict division no longer exists with today's SINUMERIK NC language. In principle, any part program in the channel can be selected and started. It then runs through in → program level 0 (main program level). Further part programs or → cycles as subprograms can be called up in the main program.

MDA

Control operating mode: Manual Data Automatic. In the MDA mode, individual program blocks or block sequences with no reference to a main program or subprogram can be input and executed immediately afterwards through actuation of the NC start key.

Messages

All messages programmed in the part program and → alarms detected by the system are displayed on the operator panel in plain text with date and time and the corresponding symbol for the cancel criterion. Alarms and messages are displayed separately.

Metric measuring system

Standardized system of units: For length, e.g. mm (millimeters), m (meters).

Mirroring

Mirroring reverses the signs of the coordinate values of a contour, with respect to an axis. It is possible to mirror with respect to more than one axis at a time.

Mode

An operating concept on a SINUMERIK controller. The following modes are defined: → Jog, → MDA, → Automatic.

Mode group

Axes and spindles that are technologically related can be combined into one mode group. Axes/spindles of a mode group can be controlled by one or more → channels. The same → mode type is always assigned to the channels of the mode group.

NC

Numerical Control: Numerical control (NC) includes all components of machine tool control: → NCK, → PLC, HMI, → COM.

Note

A more correct term for SINUMERIK controllers would be: Computerized Numerical Control

NCK

Numerical Control Kernel: Component of NC that executes the → part programs and basically coordinates the motion operations for the machine tool.

Network

A network is the connection of multiple S7-300 and other end devices, e.g. a programming device via a → connecting cable. A data exchange takes place over the network between the connected devices.

NRK

Numeric robotic kernel (operating system of → NCK)

NURBS

The motion control and path interpolation that occurs within the controller is performed based on NURBS (**N**on **U**niform **R**ational **B**-**S**plines). This provides a uniform procedure for all internal interpolations.

OEM

The scope for implementing individual solutions (OEM applications) has been provided for machine manufacturers, who wish to create their own user interface or integrate technology-specific functions in the controller.

Offset memory

Data range in the control, in which the tool offset data is stored.

Oriented spindle stop

Stops the workpiece spindle in a specified angular position, e.g. in order to perform additional machining at a particular location.

Oriented tool retraction

RETTOOL: If machining is interrupted (e.g. when a tool breaks), a program command can be used to retract the tool in a user-specified orientation by a defined distance.

Overall reset

In the event of an overall reset, the following memories of the → CPU are deleted:

- → Working memory
- Read/write area of → load memory
- → System memory
- → Backup memory

Override

Manual or programmable control feature which enables the user to override programmed feedrates or speeds in order to adapt them to a specific workpiece or material.

Part program

Series of statements to the NC that act in concert to produce a particular → workpiece. Likewise, this term applies to execution of a particular machining operation on a given → raw part.

Part program block

Part of a → part program that is demarcated by a line feed. There are two types: → main blocks and → subblocks.

Part program management

Part program management can be organized by → workpieces. The size of the user memory determines the number of programs and the amount of data that can be managed. Each file (programs and data) can be given a name consisting of a maximum of 24 alphanumeric characters.

Path axis

Path axes include all machining axes of the → channel that are controlled by the → interpolator in such a way that they start, accelerate, stop, and reach their end point simultaneously.

Path feedrate

Path feed affects → path axes. It represents the geometric sum of the feedrates of the → geometry axes involved.

Path velocity

The maximum programmable path velocity depends on the input resolution. For example, with a resolution of 0.1 mm the maximum programmable path velocity is 1000 m/min.

PCIN data transfer program

PCIN is an auxiliary program for sending and receiving CNC user data (e.g. part programs, tool offsets, etc.) via a serial interface. The PCIN program can run in MS-DOS on standard industrial PCs.

Peripheral module

I/O modules represent the link between the CPU and the process.

I/O modules are:

- → Digital input/output modules
- → Analog input/output modules
- → Simulator modules

PLC

Programmable **L**ogic **C**ontroller: → Programmable logic controller. Component of → NC: Programmable control for processing the control logic of the machine tool.

PLC program memory

SINUMERIK 840D sl: The PLC user program, the user data and the basic PLC program are stored together in the PLC user memory.

PLC programming

The PLC is programmed using the **STEP 7** software. The STEP 7 programming software is based on the **WINDOWS** standard operating system and contains the STEP 5 programming functions with innovative enhancements.

Polar coordinates

A coordinate system which defines the position of a point on a plane in terms of its distance from the origin and the angle formed by the radius vector with a defined axis.

Polynomial interpolation

Polynomial interpolation enables a wide variety of curve characteristics to be generated, such as **straight line, parabolic, exponential functions** (SINUMERIK 840D sl).

Positioning axis

Axis that performs an auxiliary motion on a machine tool (e.g. tool magazine, pallet transport). Positioning axes are axes that do not interpolate with → path axes.

Pre-coincidence

Block change occurs already when the path distance approaches an amount equal to a specifiable delta of the end position.

Program block

Program blocks contain the main program and subprograms of → part programs.

Program level

A part program started in the channel runs as a → main program on program level 0 (main program level). Any part program called up in the main program runs as a → subprogram on a program level 1 ... n of its own.

Programmable frames

Programmable → frames enable dynamic definition of new coordinate system output points while the part program is being executed. A distinction is made between absolute definition using a new frame and additive definition with reference to an existing starting point.

Programmable logic controller

Programmable logic controllers (PLCs) are electronic controllers, the function of which is stored as a program in the control unit. This means that the layout and wiring of the device do not depend on the function of the controller. The programmable logic control has the same structure as a computer; it consists of a CPU (central module) with memory, input/output modules and an internal bus system. The peripherals and the programming language are matched to the requirements of the control technology.

Programmable working area limitation

Limitation of the motion space of the tool to a space defined by programmed limitations.

Programming key

Characters and character strings that have a defined meaning in the programming language for → part programs.

Protection zone

Three-dimensional zone within the → working area into which the tool tip must not pass.

Quadrant error compensation

Contour errors at quadrant transitions, which arise as a result of changing friction conditions on the guideways, can be virtually entirely eliminated with the quadrant error compensation. Parameterization of the quadrant error compensation is performed by means of a circuit test.

R parameters

Arithmetic parameter that can be set or queried by the programmer of the → part program for any purpose in the program.

Rapid traverse

The highest traverse rate of an axis. For example, rapid traverse is used when the tool approaches the → workpiece contour from a resting position or when the tool is retracted from the workpiece contour. The rapid traverse velocity is set on a machine-specific basis using a machine data element.

Reference point

Machine tool position that the measuring system of the → machine axes references.

Rotary axis

Rotary axes apply a workpiece or tool rotation to a defined angular position.

Rotation

Component of a → frame that defines a rotation of the coordinate system around a particular angle.

Rounding axis

Rounding axes rotate a workpiece or tool to an angular position corresponding to an indexing grid. When a grid index is reached, the rounding axis is "in position".

RS-232-C

Serial interface for data input/output. Machining programs as well as manufacturer and user data can be loaded and saved via this interface.

Safety functions

The controller is equipped with permanently active monitoring functions that detect faults in the → CNC, the → PLC, and the machine in a timely manner so that damage to the workpiece, tool, or machine is largely prevented. In the event of a fault, the machining operation is interrupted and the drives stopped. The cause of the malfunction is logged and output as an alarm. At the same time, the PLC is notified that a CNC alarm has been triggered.

Scaling

Component of a → frame that implements axis-specific scale modifications.

Setting data

Data which communicates the properties of the machine tool to the NC as defined by the system software.

Softkey

A key, whose name appears on an area of the screen. The choice of softkeys displayed is dynamically adapted to the operating situation. The freely assignable function keys (softkeys) are assigned defined functions in the software.

Software limit switch

Software limit switches limit the traversing range of an axis and prevent an abrupt stop of the slide at the hardware limit switch. Two value pairs can be specified for each axis and activated separately by means of the → PLC.

Spline interpolation

With spline interpolation, the controller can generate a smooth curve characteristic from only a few specified interpolation points of a set contour.

Standard cycles

Standard cycles are provided for machining operations which are frequently repeated:

- For the drilling/milling technology
- For turning technology

The available cycles are listed in the "Cycle support" menu in the "Program" operating area. Once the desired machining cycle has been selected, the parameters required for assigning values are displayed in plain text.

Subblock

Block preceded by "N" containing information for a sequence, e.g. positional data.

Subprogram

The term "subprogram" has its origins during the time when part programs were split strictly into →main and subprograms. This strict division no longer exists with today's SINUMERIK NC language. In principle, any part program or any → cycle can be called up as a subprogram within another part program. It then runs through in the next → program level (x+1) (subprogram level (x+1)).

Synchronization

Statements in → part programs for coordination of sequences in different → channels at certain machining points.

Synchronized actions

1. Auxiliary function output

   During workpiece machining, technological functions (→ auxiliary functions) can be output from the CNC program to the PLC. For example, these auxiliary functions are used to control additional equipment for the machine tool, such as quills, grabbers, clamping chucks, etc.

2. Fast auxiliary function output

   For time-critical switching functions, the acknowledgement times for the → auxiliary functions can be minimized and unnecessary hold points in the machining process can be avoided.

Synchronized axes

Synchronized axes take the same time to traverse their path as the geometry axes take for their path.

Synchronized axis

A synchronized axis is the → gantry axis whose set position is continuously derived from the motion of the → leading axis and is, thus, moved synchronously with the leading axis. From the point of view of the programmer and operator, the synchronized axis "does not exist".

System memory

The system memory is a memory in the CPU in which the following data is stored:

- Data required by the operating system
- The operands timers, counters, markers

System variable

A variable that exists without any input from the programmer of a → part program. It is defined by a data type and the variable name preceded by the character **$**. See → User-defined variable.

Tapping without compensating chuck

This function allows threads to be tapped without a compensating chuck. By using the interpolating method of the spindle as a rotary axis and the drilling axis, threads can be cut to a precise final drilling depth, e.g. for blind hole threads (requirement: spindles in axis operation).

Text editor

See → Editor

TOA area

The TOA area includes all tool and magazine data. By default, this area coincides with the → channel area with regard to the access of the data. However, machine data can be used to specify that multiple channels share one → TOA unit so that common tool management data is then available to these channels.

TOA unit

Each → TOA area can have more than one TOA unit. The number of possible TOA units is limited by the maximum number of active → channels. A TOA unit includes exactly one tool data block and one magazine data block. In addition, a TOA unit can also contain a toolholder data block (optional).

Tool

Active part on the machine tool that implements machining (e.g. turning tool, milling tool, drill, LASER beam, etc.).

Tool nose radius compensation

Contour programming assumes that the tool is pointed. Because this is not actually the case in practice, the curvature radius of the tool used must be communicated to the controller which then takes it into account. The curvature center is maintained equidistantly around the contour, offset by the curvature radius.

Tool offset

Consideration of the tool dimensions in calculating the path.

Tool radius compensation

To directly program a desired → workpiece contour, the control must traverse an equistant path to the programmed contour taking into account the radius of the tool that is being used (G41/G42).

Transformation

Additive or absolute zero offset of an axis.

Travel range

The maximum permissible travel range for linear axes is ± 9 decades. The absolute value depends on the selected input and position control resolution and the unit of measurement (inch or metric).

User interface

The user interface (UI) is the display medium for a CNC in the form of a screen. It features horizontal and vertical softkeys.

User memory

All programs and data, such as part programs, subprograms, comments, tool offsets, and zero offsets/frames, as well as channel and program user data, can be stored in the shared CNC user memory.

User program

User programs for the S7-300 automation systems are created using the programming language STEP 7. The user program has a modular layout and consists of individual blocks.

The basic block types are:

- Code blocks

  These blocks contain the STEP 7 commands.

- Data blocks

  These blocks contain constants and variables for the STEP 7 program.

User-defined variable

Users can declare their own variables for any purpose in the → part program or data block (global user data). A definition contains a data type specification and the variable name. See → System variable.

Variable definition

A variable definition includes the specification of a data type and a variable name. The variable names can be used to access the value of the variables.

Velocity control

In order to achieve an acceptable traverse rate in the case of very slight motions per block, an anticipatory evaluation over several blocks (→ Look Ahead) can be specified.

WinSCP

WinSCP is a freely available open source program for Windows for the transfer of files.

Working area

Three-dimensional zone into which the tool tip can be moved on account of the physical design of the machine tool. See → Protection zone.

Working area limitation

With the aid of the working area limitation, the traversing range of the axes can be further restricted in addition to the limit switches. One value pair per axis may be used to describe the protected working area.

Working memory

The working memory is a RAM in the → CPU that the processor accesses when processing the application program.

Workpiece

Part to be made/machined by the machine tool.

Workpiece contour

Set contour of the → workpiece to be created or machined.

Workpiece coordinate system

The workpiece coordinate system has its starting point in the → workpiece zero-point. In machining operations programmed in the workpiece coordinate system, the dimensions and directions refer to this system.

Workpiece zero

The workpiece zero is the starting point for the → workpiece coordinate system. It is defined in terms of distances to the → machine zero.

Zero offset

Specifies a new reference point for a coordinate system through reference to an existing zero point and a → frame.

1. Settable

   A configurable number of settable zero offsets are available for each CNC axis. The offsets - which are selected by means of G functions - take effect alternatively.

2. External

   In addition to all the offsets which define the position of the workpiece zero, an external zero offset can be overridden by means of the handwheel (DRF offset) or from the PLC.

3. Programmable

   Zero offsets can be programmed for all path and positioning axes using the `TRANS` statement.

Index

C

D

E

F

G

H

I

J

K

L

M

N

O

P

R

S

T

U

V

W

X