HEIDENHAIN

J.H. Reference Manual

Questo documento è un estratto del
manuale tecnico HEIDENHAIN iTNC530

March 2003

4 Machine Parameters

4.1 What is a Machine Parameter?

A contouring control must have access to specific data (e.g., traverse distances, acceleration) before it can execute its programmed instructions. You define these data in machine parameters.

This list of machine parameters is divided into groups according to topic.

Machine parameters	Topics
10 to 999	Encoders and machines
1000 to 1399	Positioning
1400 to 1699	Operation with Velocity Feedforward Control
1700 to 1999	Operation with Following Error (Servo Lag)
2000 to 2999	Integrated Speed and Current Control
3000 to 3999	Spindle
4000 to 4999	Integral PLC
5000 to 5999	Data Interface
6000 to 6199	3-D Touch Probe
6500 to 6599	Tool Measurement with Triggering Touch Probe
7100 to 7199	Tapping
7200 to 7349	Programming and Display
7350 to 7399	Colors
7400 to 7599	Machining and Program Run
7600 to 7699	Hardware

If there is more than one input value for a single function (e.g., a separate input for each axis), the parameter number is extended by indices. Index zero is always axis 1, index one is axis 2, etc.

Example:

MP1010.0-8	Rapid traverse
MP1010.0	Rapid traverse for axis 1
MP1010.1	Rapid traverse for axis 2
MP1010.2	Rapid traverse for axis 3
MP1010.3	Rapid traverse for axis 4
MP1010.4	Rapid traverse for axis 5
MP1010.5	Rapid traverse for axis 6
MP1010.6	Rapid traverse for axis 7
MP1010.7	Rapid traverse for axis 8
MP1010.8	Rapid traverse for axis 9

Enter into OEM.SYS, using the code word `AXISNUMBER =`, the number of axes being used, so that only the necessary index parameters are displayed.

With other machine parameters you can activate specific functions. In this case, the parameters serve as on/off switches for these functions. These parameters are bit-encoded. Each bit is assigned either to an axis or a function.

4.2 The “Machine Parameter Programming” Mode of Operation

- Enter the code number 95148 to access the **Machine Parameter Programming** mode of operation

Meaning of the soft keys in the **Machine Parameter Programming** mode of operation:

Meaning of the soft keys:	
INSERT OVERWRITE	Switch between insertion and overwrite modes
MOVE WORD >>	Jump to the beginning of the next word in the line
MOVE WORD <<	Jump to the beginning of the previous word in the line
PAGE ↑	Go back one page in the machine parameter file
PAGE ↓	Go forward one page in the machine parameter file
BEGIN ↑	Jump to the beginning of the machine parameter file
END	Jump to the end of the machine parameter file
FIND	Search the machine parameter file for a text string
DELETE CHAR	Delete the character covered by the cursor
DELETE WORD	Delete the word that the cursor is in
DELETE LINE	Delete the line that the cursor is in
INSERT LINE / WORD	Reinsert last deleted word or line
	Open the selection list for power modules
	Open the selection list for motors

4.3 Input and Output of Machine Parameters

If the machine parameters have not yet been entered in a HEIDENHAIN contouring control (e.g., before commissioning), the iTNC presents the list of machine parameters after the memory test:

- Enter the values for the machine parameters either by hand on the keyboard or download them through the data interface.

4.3.1 Input Format

You can enter the input values either in decimal, binary (%) or hexadecimal ($) format.

- Enter a number for each machine parameter.

The value represents, for example, the acceleration in mm/s^2 or the analog voltage in V. You can add a comment to your entry by preceding it with a semicolon (;). Binary input (%) is the best format for machine parameters that activate individual functions bit-encoded.

Example: Disabling soft keys for file types with MP7224.0

Bit 0	HEIDENHAIN programs	.H
Bit 1	ISO programs	.I
Bit 2	Tool tables	.T
Bit 3	Datum tables	.D
Bit 4	Pallet tables	.P
Bit 5	Text files	.A
Bit 6	HELP files	.HLP
Bit 7	Point tables	.PNT

The soft keys for datum tables and text files are to be disabled:

0: Do not disable
1: Disable

Input value for MP7224.0 =	Binary	%00101000
	Hexadecimal	$28
	Decimal	40 (32+8)

Special case: Entering a formula

Only for MP1054.x (linear distance of one motor revolution) and for MP7530.x (type of dimension for transformation).

You can enter a formula instead of a fixed value. When entering the formula, you must pay attention to the case of the letters (whether they are small or capital). Functions are written small, variables are written in capitals.

Functions:

+	Addition	sin	Sine
–	Subtraction	cos	Cosine
·	Multiplication	tan	Tangent
/	Division	asin	Arc sine
log	Logarithm	acos	Arc cosine
log10	Logarithm to the base of 10	atan	Arc tangent
exp	Exponent	sqrt	Square root
()	Expressions in parentheses are solved	sqr	Square

Variable:

REF	Current position of the axis relative to the machine datum (resolution 0.0001 mm or °)

4.3.2 Activating the Machine Parameter List

After you have entered all the values for the machine parameters:

- Exit the machine parameter list by pressing the END key.

Missing or incorrect entries result in error messages from the control that prompt you to correct your entry. The following errors are displayed:

Input error	Meaning
0	No MP number found
1	Invalid MP number
2	No separator (:) found
3	Input value incorrect
4	MP doubly defined
6	MP cannot be stored

If the control does not recognize any errors, it automatically exits the machine parameter editor and is ready for operation.

If you do not make any entries in the machine parameter list during initial commissioning and exit the editor with the END key, the iTNC generates a standard machine parameter list (MP NAME). In this list the iTNC is defined as a programming station with the HEIDENHAIN standard colors. In all other machine parameters a default value is entered.

You can enter more than one machine parameter list in the iTNC:

- Select the lists with the PGM MGT key and the **SELECT** soft key. The last selected machine parameter list becomes active when you exit the machine parameter editor.

4.3.3 Changing the Input Values

A machine parameter list can be changed either with the machine parameter editor or directly through the PLC. The "List of Machine Parameters" includes the following symbols:

Symbol	Change by / Reaction
CN123	The MP is also accessible through the code number 123.
PLC	The MP can be changed via the PLC; it can also be changed in a running NC program during a strobe output.
RUN	The MP can also be changed while an NC program is running.
RESET	Changing the MP results in a reset.
REF	The axis must be moved over the reference mark again.

Manual input

▶ Call the machine parameter editor through the MOD function "code number":

- By entering the code number **95148,** you gain access to the complete list of machine parameters.
- By entering the code number **123,** you gain access to a subset of machine parameters. This subset can be changed by the user (see User's Manual). Machine parameters that can be accessed through the code number 123 are indicated in the list with the symbol CN123.

▶ To exit the machine parameter editor, press the END key.

User parameters

You can access some machine parameters without first entering a code number.

▶ In MP7330.x, define up to 16 machine parameters and define the associated dialog in MP7340.x. The dialog is shown whenever the **USER PARAMETERS** soft key is pressed (up to 37 characters).

▶ Select the MOD function **USER PARAMETER.**

Protecting the machine parameter list

To protect the current machine parameter list from being edited through the code number 95148:

▶ In the OEM.SYS file, define a new code number in the entry **MPPASSWORD =** for editing the machine parameter list. Then it is **no longer possible** to edit through the code number 95148.

To protect individual machine parameters against editing:

▶ In the **MPLOCKFILE =** entry in the OEM.SYS file, enter the path of a machine-parameter subfile. Then it is only possible to edit those machine parameters that have no value assigned in this file. If there is a difference between the current MP value and the MP value in this subfile, the control displays an error message and a window offering the value from the subfile for your acceptance.

Overwrite machine parameters

Machine parameters can be overwritten by the PLC or from an NC macro. In the **Program run, full sequence, Program run, single block** and **Positioning with manual data input** operating modes, machine parameters can be overwritten only when the drives are stationary, and not during a movement.

Warning

In the **Manual** and **Electronic Handwheel** operating modes machine parameters should not be overwritten during a movement, since this might result in critical conditions.

Changing the input values via PLC

You can also change the machine parameters through the PLC. The following modules are available for this purpose

- Module 9031 Overwrite machine parameter
- Module 9032 Read machine parameter
- Module 9310 Read the machine parameter from the run-time memory
- Module 9033 Select machine parameter file
- Module 9034 Load machine parameter subfile

The machine parameters that you can change with Module 9031 or Module 9034 are indicated with PLC in the overview.

Module 9031 Overwrite machine parameters

With this module you can overwrite the value of the given machine parameter with a new value. The input value must be a natural number with the decimal point shifted by the number of possible decimal places.

Example:

MP910.0 = 100.12 [mm] Transfer value: 1001200 (4 decimal places)

The value in the run-time memory is changed. The value from the editable machine parameter file does not change. The old value becomes valid again after the machine parameter file is edited and exited.

For non-indexed machine parameters, zero must be transferred as the index. Once the NC program has started, the module operates only during the output of an M/S/T/Q strobe.

Call only in a submit job.

Call:

```
PS    B/W/D/K   <>MP number>
PS    B/W/D/K   <>MP index>
PS    B/W/D     <>MP value>
CM    9031
PL    B/W/D     <>Error code>
                0: No error
                1: MP does not exist / is not changeable / is not changeable
                during a running program
                2: MP value out of range
                3: Error while saving (fatal error)
                4: Call was not in a submit or spawn job
                5: Call during running program without strobe
```

Error recognition:

Marker	Value	Meaning
M4203	0	MP was overwritten
	1	MP could not be overwritten

Module 9032 Read machine parameters

With this module you can read the value of the given machine parameter from the active machine parameter file. The input value is transferred as a natural number with the decimal point shifted by the number of possible decimal places.

Only the value from the editable machine parameter file is read, not any value modified in the run-time memory by PLC Module 9031.

For non-indexed machine parameters, zero must be transferred as the index.

Call only in a submit job.

Call:

```
PS    B/W/D/K    <>MP number>
PS    B/W/D/K    <>MP index>
CM    9032
PL    B/W/D      <>MP value / error code>
                 1: MP number does not exist
                 2: No separator (:)
                 3: MP value out of range
                 4: MP not found in file
                 5: No MP file found
                 6: Call was not in a submit or spawn job
                 7: MP is of the "string" type
                 8: No system memory
```

Error recognition:

Marker	Value	Meaning
M4203	0	MP was read
	1	MP could not be read from the table

Module 9310 Read the machine parameter from the run-time memory

Use this module to read the value of the given machine parameter from the run-time memory. The input value is transferred as a natural number with the decimal point shifted by the number of possible decimal places. Machine parameters whose contents exceed the 32-bit limit cannot be read.

A value is read from the run-time memory.

For non-indexed machine parameters, zero must be transferred as the index.

Call:

```
PS    B/W/D/K   <>MP number>
PS    B/W/D/K   <>MP index>
CM    9310
PL    B/W/D     <>MP value/error code>
                1: MP number does not exist
                3: MP outside value range
                6: Call was not in a submit or spawn job
                7: MP is of the "string" type
                8: No system memory
```

Error recognition:

Marker	Value	Meaning
M4203	0	MP was read
	1	Error code in W1022
W1022	20	Module was not called in a spawn job or submit job

Module 9033 Select machine parameter file

With this module you can select a new machine parameter file. If machine parameter files that set off a reset were changed, the control system will restart.

> **Warning**
>
> The module does not take any existing safety problems into account when setting off a control reset (e.g., axes and spindle coasting to a stop).

The file to be selected is checked; a faulty file is not selected. If file selection is successful, there is no return to the calling PLC program.

The file name is transferred in a string that must contain the complete path, name and file extension. Further characters, even space characters, are not permitted.

If the PLC program is created externally, ensure that lower-case letters are not used for the file name!

Once the NC program has started, the module operates only during the output of an M/S/T/Q strobe.

Call only in a submit job.

Call:

```
PS      B/W/D/K      <>String number>
CM      9033
                Note: If a new file is selected, program execution ends here.
PL      B/W/D        <>Error code>
                0: No error. File was already selected.
                1: String does not contain a valid file name.
                2: File not found.
                3: File is faulty.
                4: Incorrect string number transferred.
                5: Call was not in a submit job.
                6: Call during running program without strobe.
```

Machine parameter subfile

A machine parameter subfile can be activated via Module 9034, or from the NC program via **FN17: SYSWRITE** (also see page 9 – 22).

Module 9034 Load a machine parameter subfile

With this module you load the contents of the given machine parameter into the main memory. All MPs not listed in this file remain unchanged.

The MP file to be selected is checked. A faulty file is not loaded. If the MP file contains parameters that require a system reset, the file is not loaded.

The file name is transferred in a string that must contain the complete path, name and file extension. Further characters, even space characters, are not permitted.

If the PLC program is created externally, ensure that lower-case letters are not used for the file name!

Once the NC program has started, the module operates only during the output of an M/S/T/Q strobe.

Call only in a submit job.

Call:

PS	B/W/D/K	<>String number> 0 to 99
CM	9034	
PL	B/W/D	<>Error code> 0: No error 1: String does not contain a valid file name, or the name (including the path) is too long. 2: File not found. 3: File is faulty / contains reset parameters. 4: Incorrect string number was transferred (0 to 3). 5: Call was not in a submit job. 6: Call during running program without strobe.

4.4 List of Machine Parameters

4.4.1 Encoders and Machines

MP	Function and input	Software version and behavior	Page
MP10	Active axes Format: %xxxxxxxxxxxxxx Input: Bits 0 to 13 correspond to axes 1 to 14 0: Axis not active 1: Axis active	PLC RUN	6 – 3
MP20	Monitoring functions for the axes Format: %xxxxxxxxxxxxxx Input: Bits 0 to 13 represent axes 1 to 14 0: Monitoring not active 1: Monitoring active	PLC RUN	6 – 10
MP20.0	Absolute position of the distance-coded reference marks		
MP20.1	Amplitude of encoder signals		
MP20.2	Edge separation of encoder signals		
MP21	Monitoring functions for the spindle Format: %xx Input: Bit 0 – Spindle 1 0: Monitoring not active 1: Monitoring active Bit 1 – Spindle 2 0: Monitoring not active 1: Monitoring active	PLC RUN	6 – 10
MP21.0	Absolute position of the distance-coded reference marks		
MP21.1	Amplitude of encoder signals		
MP21.2	Edge separation of encoder signals		
MP100	Designation of axes Format: -wvucbazyxWVUCBAZYX Input: Characters 1 to 9 from the right represent axes 1 to 9	PLC RUN	6 – 3, 6 – 25
MP100.0	Traverse range 1		
MP100.1	Traverse range 2		
MP100.2	Traverse range 3		

MP	Function and input	Software version and behavior	Page
MP110.x	Assignment of position encoder inputs to the axes Input: 0: No position encoder input 1 to 6: Position encoder inputs X1 to X6 35 to 38: Position encoder inputs X35 to X38	RESET	6 – 13
MP111.x	Position encoder input for the spindle/spindles Input: 0: No position encoder input 1 to 6: Position encoder inputs X1 to X6 35 to 38: Position encoder inputs X35 to X38	REF	6 – 15, 6 – 194
MP111.0	Position encoder input for the first spindle		
MP111.1	Position encoder input for the second spindle		
MP112.x	Assignment of speed encoder inputs to the axes Input: 0: No speed encoder input 15 to 20: Speed encoder inputs X15 to X20 80 to 85: Speed encoder inputs X80 to X85	RESET	6 – 13
MP113.x	Speed encoder for the spindle/spindles Input: 0: No speed encoder input 15 to 20: Speed encoder inputs X15 to X20 80 to 85: Speed encoder inputs X80 to X85	REF	6 – 15, 6 – 197
MP113.0	Speed encoder for the first spindle		
MP113.1	Speed encoder for the second spindle		
MP115.0	Position encoder input 1 V_{PP} or 11 μA_{PP} Format: %xxxxxxxxxxx Input: Bit 0 to bit 5: Position encoder inputs X1 to X6 Bit 6 to bit 9: Position encoder inputs X35 to X38 Bit 10: No function 0: 1 V_{PP} 1: 11 μA_{PP}	RESET	6 – 8
MP115.1	Reserved Format: %xxxxxxxxxxx Input: Enter %00000000000		
MP115.2	Input frequency of the linear encoder inputs Format: %xxxxxxxxxxx Input: Bit 0 to bit 5: Position encoder inputs X1 to X6 Bit 6 to bit 9: Position encoder inputs X35 to X38 Bit 10: No function With 1 V_{PP}: 0: 33 kHz 1: 350 kHz With 11 μA_{PP}: 0: 33 kHz 1: 150 kHz		

MP	Function and input	Software version and behavior	Page
MP116.0	Only CC 424: Position encoder input 1 V_{PP} or 11 μA_{PP} Format: %xxxxxxxxxx Input: Bit 0 to bit 9: Linear encoder inputs X201 to X210 Bit 10: No function 0: 1 V_{PP} 1: 11 μA_{PP}	340 420-08, 340 422-02, 340 480-02 RESET	7 – 5
MP116.1	Only CC 424: Reserved Format: %xxxxxxxxxxx Input: Enter %00000000000		
MP116.2	Only CC 424: Input frequency of the position encoder inputs Format: %xxxxxxxxxxx Input: Bit 0 to bit 9: Linear encoder inputs X201 to X210 Bit 10: No function With 1 V_{PP}: 0: 33 kHz 1: 350 kHz With 11 μA_{PP}: 0: 33 kHz 1: 150 kHz		

MP	Function and input	Software version and behavior	Page
MP120.x	Nominal speed command outputs of the axes Input: 0: No servo-controlled axis 1 to 6: Analog outputs 1 to 6 at terminal X8 7 to 12: Analog outputs 7 to 12 at terminal X9 51 to 62: Digital output X51 to X62	RESET	6 – 13
MP121.0	Nominal speed command output of the first spindle Input: 0: No servo-controlled axis 1 to 6: Analog outputs 1 to 6 at terminal X8 7 to 12: Analog outputs 7 to 13 at terminal X9 51 to 62: Digital output X51 to X62	RESET	6 – 15
MP121.1	Nominal speed command output of the second spindle Input: 0: No servo-controlled axis 1 to 6: Analog outputs 1 to 6 at terminal X8 7 to 12: Analog outputs 7 to 13 at terminal X9 51 to 62: Digital output X51 to X62	RESET	
MP130.x	Y index of the machine parameters MP2xxx.y for the axes Input: 0 to 12	PLC RUN	6 – 13
MP131.x	Y index of the machine parameters MP2xxx.y for the spindle(s) in operating mode 0 Input: 0 to 12	PLC RUN	6 – 15
MP131.0	Index for the first spindle		
MP131.1	Index for the second spindle		
MP132.x	Y index of the machine parameters MP2xxx.y for the spindle(s) in operating mode 1 Input: 0 to 12	PLC RUN	6 – 15
MP132.0	Index for the first spindle		
MP132.1	Index for the second spindle		
MP210	Counting direction of position encoder output signals Format: %xxxxxxxxxxxxxx Input: Bits 0 to 13 represent axes 1 to 14 0: Positive 1: Negative	RESET	6 – 9

MP	Function and input	Software version and behavior	Page
MP331.x	Distance for the number of signal periods in MP332 Input: 0.0001 to +1.797693135E+308 [mm] or [°]	PLC RUN REF	6 – 7
MP332.x	Number of signal periods for the distance in MP331 Input: 1 to +1.797693135E+308	PLC RUN REF	6 – 7
MP334.x	Nominal increment between two fixed reference marks on encoders with distance-coded reference marks Input: 1 to 65 535 0: 1 000	PLC RUN REF	6 – 7
MP340.x	Interpolation factor for external interpolation Input: 0 to 99 0 = 1: No external interpolation	RESET	6 – 7
MP410	Assignment of axis keys IV and V Input: Axis designation XYZABCUVWxyzabcuvw–	PLC RUN	6 – 3
MP410.3	Axis key IV		
MP410.4	Axis key V		
MP420.x	Hirth coupling Input: 0: No Hirth coupling 1: Hirth coupling	PLC RUN	8 – 178
MP430.x	Prescribed increment for Hirth coupling Input: 0.0000 to 30.0000 [°]	PLC RUN	8 – 178
MP710.x	Backlash compensation Input: –1.0000 to +1.0000 [mm] or [°]	PLC RUN	6 – 34
MP711.x	Height of peaks during circular movement (only analog) Input: –1.0000 to +1.0000 [mm] (digital: 0)	PLC RUN	6 – 45
MP712.x	Compensation value per control loop cycle time Input: 0.000 000 to 99.999 999 [mm] (digital: 0)	PLC RUN	6 – 45
MP715.x	Height of peaks during circular movement (only analog) with M105 Input: –1.0000 to +1.0000 [mm] (digital: 0)	PLC RUN	6 – 45
MP716.x	Compensation value per control loop cycle time with M105 Input: 0.000 000 to 99.999 999 [mm] (digital: 0)	PLC RUN	6 – 45
MP720.x	Linear axis error compensation Input: –1.000 to +1.000 [mm/m]	PLC RUN	6 – 36
MP730	Selection of linear/nonlinear axis error compensation Format: %xxxxxxxxxxxxxx Input: Bits 0 to 3 represent axes 1 to 14: 0: Linear axis error compensation 1: Nonlinear axis error compensation	PLC RUN	6 – 36, 6 – 41

MP	Function and input	Software version and behavior	Page
MP750.x	Reversal error Input: –1.0000 to +1.0000 [mm] or [°]	PLC RUN	6 – 35
MP752.x	Compensation time for reversal error Input: 0 to 1000 [ms]	PLC RUN	6 – 35
MP810.x	Display mode for rotary axes and PLC auxiliary axes Input: 0.0000 to 99 999.9999 [°] 0: Display +/–99 999.9999 1: Modulo value for display	PLC RUN REF	8 – 4
MP812	Activate software limit switches for tilting axes with modulo display, M94 and encoders with EnDat interface Format: %xxxxxxxxxxxxxx Input: Bits 0 to 3 represent axes 1 to 14: 0: Software limit switch not active 1: Software limit switch active	RESET	8 – 4
MP850.x	Synchronized axes Input: 0: Master axis 1: Slave axis to axis 1 2: Slave axis to axis 2 3: Slave axis to axis 3 4: Slave axis to axis 4 5: Slave axis to axis 5 6: Slave axis to axis 6 7: Slave axis to axis 7 8: Slave axis to axis 8 9: Slave axis to axis 9	PLC RUN	6 – 89
MP855.x	Synchronization monitoring Input: 0 to 100.0000 [mm] 0: Monitoring not active	PLC RUN	6 – 91
MP860.x	Datum for synchronous control Input: 0: Datum at position after switch-on 1: Datum at reference marks 2: Axis is torque slave axis	PLC RUN	6 – 91, 6 – 96
MP910.x	Positive software limit switches, traverse range 1 (default setting after power on) Input: –99 999.9999 to +99 999.9999 [mm] or [°]	PLC RUN	6 – 23
MP911.x	Positive software limit switches, traverse range 2 Input: –99 999.9999 to +99 999.9999 [mm] or [°]	PLC RUN	6 – 23
MP912.x	Positive software limit switches, traverse range 3 Input: –99 999.9999 to +99 999.9999 [mm] or [°]	PLC RUN	6 – 23
MP920.x	Negative software limit switches, traverse range 1 (default setting after power on) Input: –99 999.9999 to +99 999.9999 [mm] or [°]	PLC RUN	6 – 23

MP	Function and input	Software version and behavior	Page
MP921.x	Negative software limit switches, traverse range 2 Input: –99 999.9999 to +99 999.9999 [mm] or [°]	PLC RUN	6 – 23
MP922.x	Negative software limit switches, traverse range 3 Input: –99 999.9999 to +99 999.9999 [mm] or [°]	PLC RUN	6 – 23
MP950.x	Datum for positioning blocks with M92 for axes 1 to 9 Input: –99 999.9999 to +99 999.9999 [mm] or [°] Values with respect to the machine datum	PLC RUN	8 – 33
MP951.x	Simulated tool-change position for TOOL CALL during mid-program startup (block scan) Input: –99 999.9999 to +99 999.9999 [mm] or [°]	PLC RUN	8 – 43
MP960.x	Machine datum Input: –1.79769313486E+308 to +1.79769313486E+308 [mm] or [°] Values with respect to the scale reference point	PLC RUN REF	6 – 105, 8 – 33

4.4.2 Positioning

MP	Function and input	Software version and behavior	Page
MP1010.x	Rapid traverse Input: 10 to 300 000 [mm/min or °/min]	PLC RUN	6 – 135
MP1011	Limit of rapid traverse on the path Input: 10 to 300 000 [mm/min or °/min]	340 420-05 PLC RUN	6 – 135
MP1020.x	Manual feed Input: 10 to 300 000 [mm/min]	PLC RUN	6 – 135
MP1030.x	Positioning window Input: 0.0001 to 2.0000 [mm]	PLC RUN	6 – 177
MP1040	Analog axes: Polarity of nominal value voltage Digital axes: Algebraic sign of the nominal speed value Format: %xxxxxxxxxxxxxx Input: Bits 0 to 13 represent axes 1 to 14 0: Positive 1: Negative		6 – 9
MP1050.x	Analog axes: Analog voltage at rapid traverse Input: 1.000 to 9.000 [V] Digital axes: without function Input: 1	PLC RUN	6 – 135
MP1054.x	Linear distance of one motor revolution Input: Analog axes: Without function Digital axes: 0 to 100.000 [mm] or [°]		6 – 176
MP1060.x	Acceleration Input: 0.001 to 100.000 [m/s^2 or $1000°/s^2$]	PLC RUN	6 – 123
MP1061	Limitation of the path acceleration Input: 0.001 to 100.000 [m/s^2 or $1000°/s^2$]	340 420-05 PLC RUN	6 – 123
MP1070	Radial acceleration Input: 0.001 to 100.000 [m/s^2 or $1000°/s^2$]	PLC RUN	6 – 167
MP1080.x	Analog axes: Integral factor for offset adjustment Input: Enter 0 to 65 535 Digital axes: No function Input: 0	PLC RUN	6 – 165
MP1086.x	Maximum permissible jerk during single-axis movements at rapid traverse for the operating modes Program Run Full Sequence, Program Run Single Block, and Positioning with Manual Data Input Input: 0: Function inactive 0.1 to 1000.0 [m/s^3 or $1000°/s^3$]	340 420-02 PLC RUN	6 – 123

MP	Function and input	Software version and behavior	Page
MP1087.x	Maximum permissible axis-specific jerk for Manual mode Input: 0.1 to 1000.0 [m/s^3 or 1000°/s^3]	PLC RUN	6 – 123
MP1089.x	Maximum permissible axis-specific jerk for Pass Over Reference Point mode Input: 0.1 to 1000.0 [m/s^3 or 1000°/s^3]	PLC RUN	6 – 123
MP1090	Maximum permissible jerk on the tool path Input: 0.1 to 1000.0 [m/s^3 or 1000°/s^3]	PLC RUN	6 – 123
MP1090.0	With machining feed rate		
MP1090.1	Beginning with feed rate from MP1092		
MP1092	Feed rate threshold from which MP1090.1 becomes effective Input: 10 to 300 000 [mm/min]	PLC RUN	6 – 123
MP1094	HSC filter Input: 0: HSC filter inactive 0.1 to 166.0: Cutoff frequency for HSC filter		6 – 123
MP1095	Nominal position value filter Input: 0: Single filter 1: Double filter	PLC RUN	6 – 123
MP1095.0	In the Program Run Full Sequence, Program Run Single Block, and Positioning With Manual Data Input operating modes		
MP1095.1	In the Manual, Handwheel, Jog Increment and Pass Over Reference Point operating modes		
MP1096	Tolerance for contour transitions at corners Input: 0: No nominal position value filter 0.001 to 3.000 [mm]	PLC RUN	6 – 124, 6 – 168
MP1096.0	With machining feed rate		
MP1096.1	With rapid traverse		
MP1097.x	Maximum permissible axis-specific jerk (single/HSC filter) Input: 0.1 to 1000.0 [m/s^3 or 1000°/s^3]	PLC RUN	6 – 124
MP1098.x	Maximum permissible axis-specific jerk (double/HSC filter) Input: 0.1 to 1000.0 [m/s^3 or 1000°/s^3]	PLC RUN	6 – 124
MP1099	Minimum filter order Input: 0 to 20	PLC RUN	6 – 124
MP1099.0	Minimum filter configuration for single filter (MP1095 = 0)		
MP1099.1	Minimum filter configuration for double filter (MP1095 = 1)		
MP1110.x	Standstill monitoring Input: 0.0010 to 30.0000 [mm]	PLC RUN	6 – 177

MP	Function and input	Software version and behavior	Page
MP1120.x	Standstill monitoring when determining the field angle Input: 0.0000 to 300.0000 [mm] or [°]	340 422-03, 340 480-03 PLC RUN	6 – 246
MP1140.x	Threshold at which the movement monitoring goes into effect Input: Analog axes: 0.030 to 10.000 [V] Digital axes: 0.030 to 10.000 [1000 min] Recommended: 0.030 [1000 min]	PLC RUN	6 – 176
MP1144.x	Motion monitor for position and speed Input: Analog axes: Without function Digital axes: 0 to 99 999.999 [mm] 0: No monitoring	PLC RUN	6 – 176
MP1146.x	Difference between the position at shutdown and the position read in via the EnDat interface Input: 0.0000 to 300.0000 [mm] or [°] 0: No difference permitted	340 420-05 PLC RUN	6 – 174
MP1150.0 MP1150.1 MP1150.2	Delay time for deleting the nominal velocity value with the erasable error message **EXCESSIVE SERVO LAG IN <AXIS>** Input: 0 to 65.535 [s] Recommended: 0 Time period for which the monitoring function is to remain off after the fast PLC input defined in MP4130.0 is set. Input: 0 to 65.535 [s] 0: Monitoring functions on Recommended: 0.2 to 0.5 Minimum time period for which the monitoring functions are to remain effective after expiration of the time from MP1150.1. Input: 0 to 65.535 [s]	PLC RUN	6 – 137, 6 – 172; 6 – 174
MP1320	Direction for traversing the reference marks Format: %xxxxxxxxxxxxxx Input: Bits 0 to 13 represent axes 1 to 14 0: Positive 1: Negative	PLC RUN	6 – 105
MP1330.x	Velocity for traversing the reference marks Input: 80 to 300 000 [mm/min]	PLC RUN	6 – 105
MP1331.x	Velocity for leaving the reference mark end position for axes 1 to 9 (only for rotary encoders MP1350 = 2) Input: 10 to 300 000 [mm/min]	PLC RUN	6 – 105
MP1340.x	Sequence for traversing the reference marks Input: 0: No evaluation of reference marks 1 to 14: Axes 1 to 14	PLC RUN REF	6 – 105

MP	Function and input	Software version and behavior	Page
MP1350.x	Type of reference-mark traverse Input: 0: Linear encoder with distance-coded reference marks (old routine) 1: Position encoder with one reference mark 2: Special type (length measurement with ROD) 3: Linear encoder with distance-coded reference marks (new routine) 4: Same as 3 except that two reference marks are evaluated 5: Encoder with EnDat interface 6: Reference pulse over fast PLC input	PLC RUN REF	6 – 106
MP1355	Double reference run Format: %xxxxxxxxxxxxxx Input: Bits 0 to 13 represent axes 1 to 14 0: Reference run as defined in MP1350.x 1: Double reference run	340 420-05 PLC RUN REF	6 – 106
MP1356.x	Distance between speed and position encoder for double reference run. Input: –99 999.999 to +99 999.999 [mm] or [°]	340 420-05 PLC RUN REF	6 – 106
MP1357.x	W1032 for double reference run Input: 0: Reset W1032 if the reference run has been over the EnDat interface of the speed encoder 1: Reset W1032 if the reference mark was traversed with the position encoder	340 422-05, 340 480-05 PLC RUN	6 – 106
MP1360.x	Fast PLC input for reference pulse Input: 0: No fast PLC input for reference pulse 1 to 5: Fast PLC input 1 to 5 (MP4130.x)	PLC RUN REF	6 – 106
MP1391	Velocity feedforward control in the MANUAL and HANDWHEEL operating modes Format: %xxxxxxxxxxxxxx Input: Bits 0 to 13 represent axes 1 to 14 0: Operation with following error (lag) 1: Operation with velocity feedforward control	PLC RUN	6 – 47, 6 – 127
MP1392	Velocity feedforward in the POSITIONING WITH MANUAL DATA INPUT, PROGRAM RUN SINGLE BLOCK and PROGRAM RUN FULL SEQUENCE operating modes Format: %xxxxxxxxxxxxxx Input: Bits 0 to 13 represent axes 1 to 14 0: Operation with following error (lag) 1: Operation with velocity feedforward control	PLC RUN	6 – 127
MP1396.x	Feedback control with velocity semifeedforward Input: 0.001 to 0.999 1: Velocity feedforward control	PLC RUN	6 – 133

4.4.3 Operation with Velocity Feedforward Control

MP	Function and input	Software version and behavior	Page
MP1410.x	Position monitoring for operation with velocity feedforward control (erasable) Input: 0.0010 to 30.0000 [mm] Recommended: 0.5 mm	PLC RUN	6 – 174
MP1420.x	Position monitoring for operation with velocity feedforward control (EMERGENCY STOP) Input: 0.0010 to 30.0000 [mm] Recommended: 2 mm	PLC RUN	6 – 174
MP1510.x	k_V factor for velocity feedforward control Input: 0.100 to 1 000.000 [(m/min)/mm]	PLC RUN	6 – 131
MP1511.x	Factor for static friction compensation Input: 0 to 16 777 215 [s]	PLC RUN	6 – 47
MP1512.x	Limitation of the amount of the static friction compensation Input: 0 to 16 777 215 [counting steps]	PLC RUN	6 – 47
MP1513.x	Feed-rate limitation for static friction compensation Input: 0 to 300 000 [mm/min]	PLC RUN	6 – 47
MP1515.x	k_V factor for velocity feedforward control effective after M105 Input: 0.100 to 20.000 [(m/min)/mm]	PLC RUN	6 – 131
MP1516.x	k_V factor for velocity semifeedforward control Input: 0.100 to 20.000 [(m/min)/mm]	PLC RUN	6 – 133
MP1521	Transient response during acceleration and deceleration Input: 1 to 255 [ms] 0: Function inactive	PLC RUN	6 – 124
MP1522	Feed-rate smoothing Input: 0 to 60 [ms] 0: Function inactive	340 422-10, 340 480-10 PLC RUN	–

4.4.4 Operation with Following Error (Servo Lag)

MP	Function and input	Software version and behavior	Page
MP1710.x	Position monitoring for operation with following error (erasable) Input: 0.0000 to 300.0000 [mm] Recommended: 1.2 · following error	PLC RUN	6 – 174
MP1720.x	Position monitoring for operation with following error (EMERGENCY STOP) Input: 0.0000 to 300.0000 [mm] Recommended: 1.4 · following error	PLC RUN	6 – 174
MP1810.x	k_V factor for control with following error Input: 0.100 to 20.000 [(m/min)/mm]	PLC RUN	6 – 129
MP1815.x	k_V factor for control with following error effective after M105 Input: 0.100 to 20.000 [(m/min)/mm]	PLC RUN	6 – 129
MP1820.x	Multiplier for the k_V factor Input: 0.001 to 1.00000	PLC RUN	6 – 136
MP1830.x	Characteristic curve kink point Input: 0.000 to 100.000 [%]	PLC RUN	6 – 136

4.4.5 Integrated Speed and Current Control

MP	Function and input	Software version and behavior	Page
MP2040	Axis groups (for drive enabling through X150/X151) Format: %xxxxxxxxxxxxxx Input: 0: Axis not assigned (disabling only through I32) 1: Axis assigned	PLC RUN	6 – 152
MP2040.0-2	Axis group 1 to 3		
MP2040.3-7	Reserved, enter %00000000000000		
MP2050	Functionality of drive enabling I32 (X42/33) Input: 0: Emergency stop for all axes, Module 9169 not effective 1: Emergency stop for all axes that are not excepted with Module 9169 2: I32 and Module 9169 have no function		6 – 152
MP2100.x	Power module model Input: Name of the selected power module (entered by the iTNC)	RESET	6 – 236
MP2150	Signal for powerfail Input: 0: AC fail 1: Powerfail and AC fail 2: Reserved 3: Powerfail		6 – 179
MP2160.x	Field weakening with synchronous motors Input: 0: No voltage-protection module 1: Voltage-protection module present 2: Limited field weakening without voltage-protection module for EcoDyn motors		6 – 164
MP2170	Waiting time between the switch-on of the drive and the drive's standby signal Input: 0.001 to 4.999 [s] 0: 2 [s]		6 – 152
MP2180.x	PWM frequency Input: 0: f_{PWM} = 5000 Hz 3200 to 3999: f_{PWM} = 3333 Hz 4000 to 4999: f_{PWM} = 4166 Hz (CC 424: 4000 Hz) 5000 to 5999: f_{PWM} = 5000 Hz 6000 to 7999: f_{PWM} = 6666 Hz 8000 to 9999: f_{PWM} = 8333 Hz (CC 424: 8000 Hz) 10000: f_{PWM} = 10000 Hz	CC 422: RESET CC 424: PLC, RUN	6 – 240

MP	Function and input	Software version and behavior	Page
MP2182.x	Cycle time of current controller at double the basic PWM frequency Input: 0: Cycle time = $1 / (2 \cdot f_{PWM})$ 1: Cycle time = $1 / f_{PWM}$	340 422-10, 340 480-10 PLC RUN	–
MP2190	DC link voltage U_Z Input: 0 to 10 000 [V] HEIDENHAIN inverters: Non-regenerative: 565 V Regenerative: 650 V		6 – 248
MP2195	Handling of status signals from HEIDENHAIN power supply units Input: Bit 0 – Status signals that are already active during control power-up. 0: Missing signals are ignored 1: Missing signals are evaluated Bit 1– $\overline{\text{ERR.UZ.GR}}$ signal 0: Error message is not suppressed 1: Error message is suppressed Bit 2 – $\overline{\text{ERR.TMP}}$ signal 0: Error message is not suppressed 1: Error message is suppressed Bit 3 – Reserved Bit 4 – $\overline{\text{ERR.IZ.GR}}$ signal 0: Error message is not suppressed 1: Error message is suppressed Bit 5 – RDY.PS signal 0: Error message is not suppressed 1: Error message is suppressed Bit 6 – $\overline{\text{ERR.ILEAK}}$ signal 0: Error message is not suppressed 1: Error message is suppressed Bit 7 – Reserved	340 420-06	6 – 186
MP2200.x	Motor model Input: Name of the selected motor (entered by the iTNC)	RESET	6 – 236
MP2202.x	Overwrite "Line count" from the motor table Input: *: Input from the motor table active 0: No speed encoder (volts-per-hertz control mode) 1 to 999 999	340 420-05 RESET	6 – 236
MP2204.x	Overwrite "Counting direction" from the motor table Input: *: Input from the motor table active +: Positive counting direction –: Negative counting direction	340 420-05 RESET	6 – 236

MP	Function and input	Software version and behavior	Page
MP2206.x	Overwrite "Type of encoder" from the motor table Input: *: Input from the motor table active 0: No speed encoder (volts-per-hertz control mode) 1: Incremental rotary encoder with Z1 track 2: Absolute rotary encoder with EnDat interface (aligned) 3: Absolute linear encoder with EnDat interface 4: Incremental linear encoder 5: Absolute rotary encoder with EnDat interface (not aligned) 6: Incremental rotary encoder without Z1 track 7:Incremental rotary encoder with distance-coded reference marks (not aligned) 8: Incremental linear encoder with distance-coded reference marks (not aligned)	340 420-05 RESET	6 – 236

MP	Function and input	Software version and behavior	Page
MP2220.x	Monitoring functions Format: %xxxxxxxxxxxxxxxx Input: Bit 0 – Monitoring the reference mark 0: Monitoring active 1: Monitoring inactive Bit 1 – Monitoring the direction of rotation 0: Monitoring active 1: Monitoring inactive Bit 2 – Power limit of spindle with $\overline{\text{ERR.IZ.GR}}$ (only for HEIDENHAIN inverters, except UE 2xx) 0: Power limit active 1: Power limit inactive (All HEIDENHAIN inverters except UE 2xx) Bit 3 – Switching off the controller when the motor brakes are activated 0: Suppress vibrations 1: Vibrations are allowed CC 422: Bit 4 to bit 8 reserved Bit 4 – Only CC 424: Monitoring for excessive temperature 0: Active 1: Inactive Bit 5 – Only CC 424: Monitoring for insufficient temperature 0: Active 1: Inactive Bit 6 – Reserved Bit 7– Only CC 424: Monitoring of encoder input frequency 0: Active 1: Inactive Bit 8 – Only CC 424: Adjust mechanical offset by gradually increasing the k_V factor 0: Active 1: Inactive Bits 9 to 15: Reserved	PLC RUN	6 – 162; 6 – 187, 6 – 197, 7 – 9
MP2230.x	Factor for motor current during test of motor brake Input: 0.1 to 30.0 [· motor current] 0: No test of motor brakes, or motor without brake	340 420-08	6 – 188
MP2232.x	Maximum permissible path during test of motor brakes Input: 0 to 10.0000 [mm] or [°]	340 420-08	6 – 188
MP2234.x	Internal triggering of the motor brakes via the PWM interface Format: %xx Input: Bit 0 – 0: Signal is transmitted 1: Signal is not transmitted Bit 1– reserved	340 422-06, 340 480-06 PLC RUN	6 – 187

MP	Function and input	Software version and behavior	Page
MP2250.x	Only CC 424: Determining the field angle without motor motion Input: 0: Same as input value 2 1: Reserved 2: Method 2 (brakes applied) 3: Method 3 (same as Method 2, but motor brake is not applied)	340 422-03, 340 480-03 PLC RUN	7 – 19
MP2252.x	Only CC 424: Reserved Input: Enter 0	340 422-03, 340 480-03 PLC RUN	7 – 19
MP2254.x	Determining the field angle Input: 0: Field angle is determined during operation; soft key has no function (without plausibility test) 1: Only CC 422: Field angle is determined via soft key; motor motion is permitted 2: Only CC 424: Field angle is determined via soft key; motor motion is permitted (with plausibility test)	340 420-09 PLC RUN	6 – 244, 7 – 15
MP2256.x	Determined field angle Input: 0: Field angle does not need to be determined, or has not been determined	340 422-03, 340 480-03 PLC RUN	6 – 247, 7 – 22
MP2257.x	Control or encoder identification for the field angle from MP2256.x Input: 0: Field angle does not need to be determined, or has not been determined	340 422-03, 340 480-03 PLC RUN	6 – 247, 7 – 22
MP2302.x	Reference value for I^2t monitoring of motor Input: 0 to 1000.000 [· rated current of motor] 0: I^2t monitoring of motor switched off 1: Rated current of motor as reference value		6 – 184
MP2304.x	Reference value for I^2t monitoring of power module Input: 0 to 1000.000 [· rated current of power module] 0: I^2t monitoring of power module switched off 1: Rated current of power module as reference value	340 420-06	6 – 184
MP2308.x	Time between output of the braking signal $\overline{BRK}$ and switching off of the controller (overlap time) Input: 0.001 to 0.500 [s] 0: 0.200 s	340 420-06	6 – 187
MP2312.x	Reference value for utilization of feed motors for axes 1 to 9 Input: 0 to 1000.000 [· rated current of motor] 0 or 1: Reference value is rated current of motor		6 – 185

MP	Function and input	Software version and behavior	Page
MP2390.x	Maximum braking power Input: 0.1 to 3 000.000 [kW] 0: Braking power is not limited		6 – 159
MP2392.x	Power limit Input: 0: No power limit 0.1 to 3000.000 [kW]		6 – 162
MP2394.x	Maximum braking power during a power fail Input: 0.1 to 3 000.000 [kW] 0: Braking power is not limited		6 – 159
MP2396.x	Maximum torque Input: 0.1 to 30 000.0 [Nm] 0: Torque is not limited	PLC	6 – 162
MP2420.x	Proportional factor of the current controller Input: 0.00 to 9999.99 [VA]		6 – 156
MP2430.x	Integral factor of the current controller Input: 0.00 to 9999.99 [V/As]		6 – 156
MP2500.x	Proportional factor of the shaft speed controller Input: 0 to 1 000 000.000 [As]	PLC RUN	6 – 141
MP2510.x	Integral factor of the shaft speed controller Input: 0 to 100 000 000 [A]	PLC RUN	6 – 141
MP2512.x	Limiting the integral factor of the speed controller Input: 0.000 to 30.000 [s] (realistic values: 0.1 to 2.0)	PLC RUN	6 – 47, 6 – 147
MP2520.x	Differential factor of the shaft speed controller Input: 0 to 1.0000 [As]	PLC RUN	6 – 143
MP2530.x	PT_2 element of the shaft speed controller (2nd-order delay) Input: 0 to 1.0000 [s]	PLC RUN	6 – 144
MP2540.x	Band-rejection filter damping Input: 0.0 to 18.0 [dB]	PLC RUN	6 – 144

MP	Function and input	Software version and behavior	Page
MP2542.x	Only CC 424: Damping the band-rejection filter for filter 1 Input: 0 to 99.0 [dB]	PLC RUN	7 – 11
MP2543.x	Only CC 424: Damping the band-rejection filter for filter 2 Input: 0 to 99.0 [dB]	PLC RUN	7 – 11
MP2544.x	Only CC 424: Damping the band-rejection filter for filter 3 Input: 0 to 99.0 [dB]	PLC RUN	7 – 11
MP2545.x	Only CC 424: Damping the band-rejection filter for filter 4 Input: 0 to 99.0 [dB]	PLC RUN	7 – 11
MP2546.x	Only CC 424: Damping the band-rejection filter for filter 5 Input: 0 to 99.0 [dB]	PLC RUN	7 – 11
MP2550.x	Band-rejection filter for center frequency Input: 0.0 to 999.9 [Hz]	PLC RUN	6 – 144
MP2552.x	Only CC 424: Center frequency of band-rejection filter for filter 1 Input: 0 to 30000.0 [Hz]	PLC RUN	7 – 11
MP2553.x	Only CC 424: Center frequency of band-rejection filter for filter 2 Input: 0 to 30000.0 [Hz]	PLC RUN	7 – 11
MP2554.x	Only CC 424: Center frequency of band-rejection filter for filter 3 Input: 0 to 30000.0 [Hz]	PLC RUN	7 – 11
MP2555.x	Only CC 424: Center frequency of band-rejection filter for filter 4 Input: 0 to 30000.0 [Hz]	PLC RUN	7 – 11
MP2556.x	Only CC 424: Center frequency of band-rejection filter for filter 5 Input: 0 to 30000.0 [Hz]	PLC RUN	7 – 11
MP2560.x	Low-pass filter Input: 0: No low-pass filter 1: 1st-order low-pass filter 2: 2nd-order low-pass filter	PLC RUN	6 – 143
MP2560.x	Only CC 424: Filter order of the low-pass filter Input: 0 to 20	340 420-09 PLC RUN	7 – 11

MP	Function and input	Software version and behavior	Page
MP2562.x	Only CC 424: Filter type for filter 1 Input: 0: No filter 1: PT2 low-pass filter (speed controller) 2: Band-rejection filter (speed controller) 11: PT2 low-pass filter (position controller) 12: Band-rejection filter (position controller)	PLC RUN	7 – 11
MP2563.x	Only CC 424: Filter type for filter 2 Input: 0: No filter 1: PT2 low-pass filter (speed controller) 2: Band-rejection filter (speed controller) 11: PT2 low-pass filter (position controller) 12: Band-rejection filter (position controller)	PLC RUN	7 – 11
MP2564.x	Only CC 424: Filter type for filter 3 Input: 0: No filter 1: PT2 low-pass filter (speed controller) 2: Band-rejection filter (speed controller) 11: PT2 low-pass filter (position controller) 12: Band-rejection filter (position controller)	PLC RUN	7 – 11
MP2565.x	Only CC 424: Filter type for filter 4 Input: 0: No filter 1: PT2 low-pass filter (speed controller) 2: Band-rejection filter (speed controller) 11: PT2 low-pass filter (position controller) 12: Band-rejection filter (position controller)	PLC RUN	7 – 11
MP2566.x	Only CC 424: Filter type for filter 5 Input: 0: No filter 1: PT2 low-pass filter (speed controller) 2: Band-rejection filter (speed controller) 11: PT2 low-pass filter (position controller) 12: Band-rejection filter (position controller)	PLC RUN	7 – 11
MP2572.x	Only CC 424: Bandwidth of band-rejection filter for filter 1 Input: 0 to 30000.0 [Hz]	PLC RUN	7 – 12
MP2573.x	Only CC 424: Bandwidth of band-rejection filter for filter 2 Input: 0 to 30000.0 [Hz]	PLC RUN	7 – 12
MP2574.x	Only CC 424: Bandwidth of band-rejection filter for filter 3 Input: 0 to 30000.0 [Hz]	PLC RUN	7 – 12
MP2575.x	Only CC 424: Bandwidth of band-rejection filter for filter 4 Input: 0 to 30000.0 [Hz]	PLC RUN	7 – 12
MP2576.x	Only CC 424: Bandwidth of band-rejection filter for filter 5 Input: 0 to 30000.0 [Hz]	PLC RUN	7 – 12
MP2590.x	Braking ramp in an emergency stop Input: 0.1 to 999.9 [rpm/ms] 0: Function inactive	PLC RUN	6 – 158

MP	Function and input	Software version and behavior	Page
MP2600.x	Acceleration feedforward Input: 0 to 100.0000 [A/(rev/s)]	PLC	6 – 147
MP2602.x	IPC time constant T_1 Input: 0.0001 to 1.0000 [s] 0: IPC inactive	PLC RUN	6 – 149
MP2604.x	IPC time constant T_2 Input: 0.0001 to 1.0000 [s] 0: IPC inactive	PLC RUN	6 – 149
MP2606.x	Following error in the jerk phase Input: 0.000 to 10.000	PLC RUN	6 – 149
MP2607.x	Damping factor for active damping Input: 0 to 30.000 0: No damping 1.5: Typical damping factor	340 422-03, 340 480-03 PLC RUN	6 – 145
MP2608.x	Damping time constant for active damping Input: 0.000 to 0.9999 [s] 0: No damping 0.005 to 0.02: Typical damping time constant	340 422-03, 340 480-03 PLC RUN	6 – 145
MP2610.x	Friction compensation at low speeds (effective only with velocity feedforward control) Input: 0 to 30.0000 [A] 0: No friction compensation (or axis is analog)	PLC RUN	6 – 48
MP2610.x	Only CC 424: Low-speed friction compensation Input: 0 to 30.0000 [A] (effective value) 0: No friction compensation	PLC RUN	7 – 13
MP2612.x	Delay of the friction compensation (effective only with velocity feedforward control) Input: 0.0000 to 1.0000 [s] (typically: 0.015 s) 0: No friction compensation (or axis is analog)	PLC RUN	6 – 48
MP2612.x	Only CC 424: Distance before the reversal point from which a reduction of the current from MP2610.x is to go into effect. Input: 0.000 to 1.000 [mm] or [°] 0: No friction compensation 0.1: Typical input value	PLC RUN	7 – 13
MP2614.x	Only CC 424: Distance after the reversal point from which a reduction of the current from MP2610.x is to go into effect. Input: 0.000 to 1.000 [mm] or [°] 0: Friction compensation same as CC 424 0.1: Typical input value	PLC RUN	7 – 13

MP	Function and input	Software version and behavior	Page
MP2620.x	Friction compensation Input: 0 to 100.000 [A] 0: No friction compensation (or axis is analog)	PLC RUN	6 – 48
MP2630.x	Holding current Input: –30.000 to +30.000 [A]	PLC RUN	6 – 150
MP2900.x	Tensioning torque between master and slave for master-slave torque control (entry for the slave axis) Input: –100.00 to +100.00 [Nm]	PLC	6 – 99
MP2910.x	P factor of the torque controller for master-slave torque control (entry for the slave axis) Input: 0.00 to 999.99 [1/(Nm · min)]	PLC	6 – 99
MP2920.x	Factor for variable torque distribution of the master-slave torque control (entry for the slave axis) Input: 0.000 to 100.000 1: Master and slave axes have identical motors	PLC	6 – 99
MP2930.x	Speed compensation ratio for master-slave torque control (entry for the slave axis) Input: –100.00 to +100.00 [%]	PLC	6 – 99

4.4.6 Spindle

MP	Function and input	Software version and behavior	Page
MP3010	Output of speed, gear range Input: 0: No output of spindle speed 1: Speed code if the speed changes 2: Speed code at every TOOL CALL 3: Nominal speed value always, G code if the gear range shifts 4: Nominal speed value always, G code at every TOOL CALL 5: Nominal speed value always, no G code 6: Same as 3, but with controlled spindle for orientation 7: Same as 4, but with controlled spindle for orientation 8: Same as 5, but with controlled spindle for orientation	PLC RUN	6 – 193
MP3011	Function of analog output S, if MP3010 < 3 Input: 0: No special function 1: Voltage is proportional to the current contouring feed rate, depending on MP3012 2: Voltage is defined as through Module 9130 3: Voltage is defined through M functions (M200 to M204)		8 – 204
MP3012	Feed rate from output of an analog voltage of 10 V, MP3011 = 1 Input: 0 to 300 000 [mm/min]		8 – 204
MP3013.x	Characteristic curve kink points (velocity) for output of the analog voltage with M202 Input: 10 to 300 000 [mm/min]	PLC RUN	8 – 205
MP3014.x	Characteristic curve kink points (voltage) for output of the analog voltage with M202 Input: 0.000 to 9.999 [V]	PLC RUN	8 – 205
MP3020	Speed range for S code output Format: xxyyz xx: S code for minimum speed yy: S code for maximum speed z: Speed increment Input: 0 to 99 999	PLC RUN	6 – 206

MP	Function and input	Software version and behavior	Page
MP3030	Behavior of the spindle Input: Bit 0 – 0: Axis stop for TOOL CALL S 1: No axis stop for TOOL CALL S Bit 1: Zero spindle speed when switching to another gear range 0: Reduce speed to 0 1: Do not reduce speed to 0	PLC RUN	6 – 202, 8 – 207
MP3120	Zero speed permitted Input: 0: S = 0 allowed 1: S = 0 not allowed	PLC RUN	6 – 201
MP3130	Polarity of the nominal spindle speed Input: 0: M03 positive, M04 negative 1: M03 negative, M04 positive 2: M03 and M04 positive 4: M03 and M04 negative	PLC RUN	6 – 200
MP3140	Counting direction of spindle position encoder output signals Input: 0: Positive counting direction with M03 1: Negative counting direction with M03	PLC RUN	6 – 200
MP3142	Line count of the spindle position encoder Input: 100 to 30000 [lines]	PLC RUN	6 – 194
MP3143	Mounting configuration of the spindle position encoder Input: 0: Position encoder directly on the first spindle 1: Position encoder via transmission (ratio in MP3450.x and MP3451.x); X30 pin 1: reference pulse 2: Position encoder via transmission (ratio in MP3450 and MP3451); X30 pin 1: reference pulse release 3: Same as input value 1, except that the second reference pulse is evaluated.	PLC RUN	6 – 194
MP3210.0-7	Analog nominal spindle voltage at rated speed for the gear ranges 1 to 8 Input: 0 to 100.000 [V] Digital spindle motor revolutions at rated speed for the gear ranges 1 to 8 Input: 0 to 100.000 [1000 rpm]	PLC RUN	6 – 201

MP	Function and input	Software version and behavior	Page
MP3240.1	Analog spindle: Minimum nominal value voltage Input: 0 to 9.999 [V] Digital spindle: Minimum motor speed Input: 0 to 9.999 [1000 rpm]	PLC RUN	6 – 201, 6 – 202
MP3240.2	Analog spindle: Spindle jog voltage for gear shifting (M4009/M4010) Input: 0 to 9.999 [V] Digital spindle: Motor speed for gear shifting (M4009/ M4010) Input: 0 to 9.999 [1000 rpm]		
MP3310	Limitation for spindle speed override Input: 0 to 150 [%]	PLC RUN	6 – 204
MP3310.0	Upper limit		
MP3310.1	Lower limit		
MP3411.0-7	Ramp gradient of the spindle with M03 and M04 for gear ranges 1 to 8 Input: Analog axes: 0 to 1.999 [V/ms] Digital axes: 0 to 1.999 [1000 rpm/ms]	PLC RUN	6 – 199
MP3412	Multiplication factor for MP3411.x Input: 0.000 to 1.999	PLC RUN	6 – 199, 6 – 210, 6 – 215, 6 – 219
MP3412.0	With M05		
MP3412.1	With oriented spindle stop		
MP3412.2	With tapping with floating tap holder		
MP3412.3	With rigid tapping		
MP3415	Overshoot behavior of the spindle with M03, M04 and M05 Input: 0 to 1000 [ms]	PLC RUN	6 – 199, 6 – 210, 6 – 215, 6 – 219
MP3415.0	With M03, M04 and M05		
MP3415.1	For oriented spindle stop		
MP3415.2	With tapping		
MP3415.3	With rigid tapping		
MP3420	Spindle positioning window Input: 0 to 360.0000 [°]	PLC RUN	6 – 210
MP3430	Deviation of the reference mark from the desired position (spindle preset) Input: 0 to 360 [°]	PLC RUN	6 – 210
MP3440.0-7	k_V factor for spindle orientation for gear ranges 1 to 8 Input: 0.1 to 10 [(1000°/ min) /°]	PLC RUN	6 – 210

MP	Function and input	Software version and behavior	Page
MP3450.0-7	Number of spindle position-encoder revolutions for gear ranges 1 to 8 Input: 0 to 65 535 0: No transmission	PLC RUN	6 – 194
MP3451.0-7	Number of spindle revolutions for gear ranges 1 to 8 Input: 0 to 65 535 0: No transmission	PLC RUN	6 – 194
MP3510.0-7	Rated speed for the gear ranges 1 to 8 Input: 0 to 99 999.999 [rpm]	PLC RUN	6 – 201
MP3515.0-7	Maximum spindle speed for gear ranges 1 to 8 Input: 0 to 99 999.999 [rpm]	PLC RUN	6 – 204
MP3520.0 MP3520.1	Speed activation through marker M4011 Input: 0 to 99 999.999 [rpm] Spindle speed for oriented stop Input: 0 to 99 999.999 [rpm]	PLC RUN	6 – 210, 6 – 213

4.4.7 Integral PLC

MP	Function and input	Software version and behavior	Page
MP4000.0-31	Options for the conditional compilation of the PLC program		9 – 16
MP4020	PLC functions Format: %xxxxxxxxxxxxx Input: Bit 0 to bit 4: Reserved Bit 5: Single or double spindle operation 0: Single-spindle operation 1: Double-spindle operation Bit 6 – Reserved Bit 7 – Transferring the values of the Pt 100 inputs 0: Accept values at a change rate of 1 K/s 1: Accept results immediately Bit 8 – Behavior after an ext. emergency stop 0: “Approach position” is not automatically activated 1: “Approach position” is automatically activated Bit 9 – Behavior of a simulated key 0: Simulated key is transferred immediately to the NC 1: Simulated key is processed first by an active PLC window before being transferred to the NC Bit 10 – Behavior of a locked key 0: Locked key only works on the active PLC window 1: Locked key works on neither the active PLC window nor on the NC Bit 11 – PLC counter in MP4120.x 0: Input in PLC cycles 1: Input in seconds Bit 12 – Font size in PLC window 0: Automatic adaptation of font size to screen 1: Font size for BF 120	RESET	6 – 137, 6 – 221, 8 – 119, 8 – 172
MP4030	Assignment of physical to logical PL Input: 0: First logical PL 1: Second logical PL 2: Third logical PL 3: Fourth logical PL	PLC RUN	8 – 161
MP4030.0	First physical PL		
MP4030.1	Second physical PL		
MP4030.2	Third physical PL		
MP4030.3	Fourth physical PL		

MP	Function and input	Software version and behavior	Page
MP4040	Set PLC output after shutdown	340 420-03 PLC RUN	8 – 56
MP4041	Time after shutdown until setting of the PLC output from MP4042 Input: 0 to 1000 [s]	340 420-03 PLC RUN	8 – 56
MP4042	PLC output to be set after shutdown Input: 0 to 31	340 420-03 PLC RUN	8 – 56
MP4043	Switch off outputs that cannot be switched off by emergency stop after 250-ms delay Input: %xxxxxxxxxxxxxxxx Bits 0 to 15 correspond to O0 to O15 0: Do not switch off output with delay 1: Switch off output with delay	340 422-07, 340 480-07 Only until 340 422-09, 340 480-09 PLC RUN	–
MP4044	Switch off outputs that cannot be switched off by emergency stop after 250-ms delay Input: %xxxxxxxx Bits 0 to 7 correspond to O16 to O23 0: Do not switch off output with delay 1: Switch off output with delay	340 422-07, 340 480-07 Only until 340 422-09, 340 480-09 PLC RUN	–
MP4045	Switch off outputs that cannot be switched off by emergency stop after 250-ms delay Input: % xxxxxxx Bits 0 to 6 correspond to O24 to O30 0: Do not switch off output with delay 1: Switch off output with delay	340 420-08 Only until 340 422-09, 340 480-09 PLC RUN	8 – 165
MP4050.0-8	Traverse distance for lubrication of axes 1 to 9 Input: 0 to 99 999.999 [m or 1000°]	PLC RUN	6 – 24
MP4060.0-3	Outputs that are to be switched off with the delay from MP4061.x when all outputs are switched off Input: 0 to 30 –1: Do not switch off output with delay	340 422-09, 340 480-09 PLC	–
MP4061.0-3	Delay time for switching off the outputs in MP4060.x Input: 0 to 5.000 [s]	340 422-09, 340 480-09 PLC	–
MP4070	Compensation amount per PLC cycle for lagged-tracking axis error compensation Input: 0.0001 to 0.5000 [mm]	PLC RUN	6 – 42

MP	Function and input	Software version and behavior	Page
MP4110.0-47	Run time PLC timer T0 to T47 Input: 0 to 1 000 000.000 [s]	PLC RUN	9 – 49
MP4111.96-x	Run time PLC timer T96 to x (defined in OEM.SYS) Input: 0 to 1 000 000.000 [s]	PLC RUN	9 – 49
MP4120.0-47	PLC counter preset value Input: 0 to 1 000 000.000 [s or PLC cycles, depending on MP4020, bit 11]	PLC RUN	9 – 52
MP4130.0 MP4130.1 MP4130.2-5	Number of the high-speed PLC input for switching off the monitoring functions Reserved Numerical designation for fast PLC inputs Input: 0 to 255 [no. of the PLC input]		6 – 172, 9 – 53
MP4131.0 MP4131.1 MP4131.2-5	Activation criterion for fast PLC input for switching off the monitoring functions Reserved Activation criterion for fast PLC inputs Input: 0: Activation at low level 1: Activation at high level		6 – 172, 9 – 53
MP4210.0-47	Setting a number in the PLC (D768 to D956) Input: –99 999.9999 to +99 999.9999		6 – 213, 9 – 44
MP4220.0-4	Setting a number in the PLC (W960 to W968) Input: 10 to 30 000		9 – 44
MP4230.0-31	Setting a number in the PLC (Module 9032) The number of indexes can be increased via an entry in OEM.SYS. Input: –99 999.9999 to +99 999.9999		9 – 44
MP4231.0-31	Setting a number in the PLC (Module 9032) Input: –99 999.9999 to +99 999.9999		9 – 44
MP4310.0-6	Setting a number in the PLC (W976 to W988, M4300 to M4411) Input: 10 to 30 000		9 – 44

4.4.8 Configuration of the Data Interface

MP	Function and input	Software version and behavior	Page
MP5000	Disable data interfaces Input: 0: No interface disabled 1: RS-232-C/V.24 interface disabled 2: RS-422/V.11 interface disabled 3: RS-232-C/V.24 and RS-422/V.11 interfaces disabled	PLC RUN	10 – 15
MP5020	Configuration of the data interface Format: %xxxxxxxx Input: Bit 0 – 0: 7 data bits 1: 8 data bits Bit 1 – 0 : Any BCC character 1 : BCC not control character Bit 2 – 0: Transmission stop by RTS not active 1: Active Bit 3 – 0: Transmission stop by DC3 not active 1: Active Bit 4 – 0: Character parity even 1: Odd Bit 5 – 0: Character parity not desired 1: Desired Bit 6 = 0, Bit 7 = 0: 1 stop bit Bit 6 = 1, Bit 7 = 0: 2 stop bits Bit 6 = 0, Bit 7 = 1: 1 stop bit Bit 6 = 1, Bit 7 = 1: 1 stop bit	PLC RUN CN123	10 – 18
MP5020.0	Operating mode EXT1		
MP5020.1	Operating mode EXT2		
MP5020.2	Operating mode EXT3 (PLC)		
MP5020.3	Operating mode EXT4 (PLC)		
MP5030	Data transfer protocol Input: 0 = standard data transfer protocol 1 = blockwise transfer 2 = without protocol (only for MP5030.2)	PLC RUN CN123	10 – 18
MP5030.0	Operating mode EXT1		
MP5030.1	Operating mode EXT2		
MP5030.2	Operating mode EXT3 (PLC)		
MP5030.3	Operating mode EXT4 (PLC)		

MP	Function and input	Software version and behavior	Page
MP5040	Data transfer rate in operating mode EXT3 (data transfer through PLC) Input: 0: 110 bps 1: 150 bps 2: 300 bps 3: 600 bps 4: 1200 bps 5: 2400 bps 6: 4800 bps 7: 9600 bps 8: 19200 bps 9: 38400 bps 10: 57600 bps 11: 115 200 bps	PLC RUN	10 – 30
MP5040.0	Operating mode EXT3 (PLC)		
MP5040.1	Operating mode EXT4 (PLC)		

4.4.9 3-D Touch Probe

MP	Function and input	Software version and behavior	Page
MP6010	Selection of the touch probe Input: 0: Touch probe with cable transmission (TS 120, TS 220) 1: Touch probe with infrared transmission (TS 632) 2: Touch probe with infrared transmission (TS 640, TS 440)	PLC CN123	8 – 180
MP6120	Probing feed rate Input: 1 to 3000 [mm/min]	PLC RUN CN123	8 – 184
MP6130	Maximum measuring range Input: 0.001 to 99 999.9999 [mm]	PLC RUN CN123	8 – 184
MP6140	Setup clearance over measuring point Input: 0.001 to 99 999.9999 [mm]	PLC RUN CN123	8 – 184
MP6150	Rapid traverse in probing cycle Input: 10 to 20 000 [mm/min]	PLC RUN CN123	8 – 184
MP6160	M function for probing from opposite directions Input: –1: Spindle orientation directly by NC 0: Function inactive 1 to 999: Number of the M function for spindle orientation through PLC	PLC RUN CN123	8 – 187
MP6161	M function for orienting the touch probe before every measuring process Input: –1: Spindle orientation directly by the NC 0: Function inactive 1 to 999: Number of the M function	PLC RUN CN123	8 – 185
MP6162	Orientation angle Input: 0 to 359.9999 [°]	PLC RUN CN123	8 – 185
MP6163	Minimum difference between the current spindle angle and MP6162 before executing an oriented spindle stop Input: 0 to 3.0000 [°]	PLC RUN CN123	8 – 185

MP	Function and input	Software version and behavior	Page
MP6165	Orient the probe before approaching with Cycle 0 or 1, or with manual probing Input: 0: Probe is not oriented before each probing 1: Probe is oriented and always deflected in the same direction	PLC RUN CN123	8 – 185
MP6170	Number of measurements in a programmed measurement (touch probe block) Input: 1 to 3	PLC RUN CN123	8 – 188
MP6171	Confidence range for programmed measurement (MP6170 > 1) Input: 0.002 to 0.999 [mm]	PLC RUN CN123	8 – 188
MP6180	Coordinates of the ring gauge center for Probing Cycle 2 with respect to the machine datum (traverse range 1) Input: 0 to +99 999.9999 [mm]	PLC CN123	8 – 187
MP6180.0	X coordinate		
MP6180.1	Y coordinate		
MP6180.2	Z coordinate		
MP6181	Coordinates of the ring gauge center for Probing Cycle 2 with respect to the machine datum (traverse range 2) Input: 0 to +99 999.9999 [mm]	PLC CN123	8 – 187
MP6181.0	X coordinate		
MP6181.1	Y coordinate		
MP6181.2	Z coordinate		
MP6182	Coordinate of the ring gauge center for Probing Cycle 2 with respect to the machine datum (traverse range 3) Input: 0 to +99 999.9999 [mm]	PLC CN123	8 – 188
MP6182.0	X coordinate		
MP6182.1	Y coordinate		
MP6182.2	Z coordinate		
MP6185	Distance of probing point below ring top surface during calibration Input: +0.001 to +99 999.9999 [mm]	PLC CN123	8 – 188

4.4.10 Tool Measurement with TT

MP	Function and input	Software version and behavior	Page
MP6500	Tool measurement with TT 130 Format: %xxxxxxxxxxxxxxx Input: Bit 0 – Cycles for tool measurement 0: Locked 1: Not locked Bit 1 – 0: Tool radius measurement allowed. Tool length measurement with rotating spindle 1: Tool radius measurement and individual tooth measurement disabled Bit 2 – 0: Tool length measurement with rotating spindle (bit 1=1) 1: Tool length measurement with rotating spindle, only if a tool radius offset (**TT: R-OFFS**) has been entered in the tool table Bit 3 – 0: Tool measurement with spindle orientation 1: Tool measurement without spindle orientation. Individual tooth measurement not possible. Tool radius measurement possibly faulty. Bit 4 – 0: Automatically determine speed 1: Always use minimum spindle speed Bit 5 – NC stop during **Tool checking** 0: The NC program is not stopped when the breakage tolerance is exceeded. 1: If the breakage tolerance is exceeded, the NC program is stopped and the error message **Tool broken** is displayed. Bit 6 – NC stop during **tool measurement** 0: The NC program is not stopped when the breakage tolerance is exceeded. 1: If the breakage tolerance is exceeded, the NC program is stopped and the error message **Touch point inaccessible** is displayed.	PLC RUN	8 – 195, 8 – 196, 8 – 196, 8 – 198, 8 – 200, 8 – 202, 8 – 202

MP	Function and input	Software version and behavior	Page
MP6500	Tool measurement with TT 130 Format: %xxxxxxxxxxxxxxx Input: Bit 7 – Reserved Bit 8 – Probing routine 0: Probe contact is probed from several directions 1: Probe contact is probed from one direction Bit 9 – Automatic measurement of the direction of the probe contact basic rotation (bit 8 = 1) 0: Basic rotation is not measured 1: Basic rotation of the probe element is automatically measured Bit 10 – Probing routine (bit 8 = 1) 0: Pre-positioning to starting point in all three principal axes 1: Pre-positioning to starting point in the tool axis and in the axis of the probing direction (MP6505) (bit 9 = 0) Bit 11 – **Tool checking** and changing in the tool table 0: After **Tool checking** the tool table is changed 1: After **Tool checking** the tool table is not changed Bit 12 – PLC datum shift 0: Do not include 1: Include Bit 13 – 0: Tool is measured in the tilt position in which the tool touch probe was also calibrated 1: Tool is measured in another tilt position Bit 14 – Tool measurement with number of teeth = 0 0: Tool measurement with rotating spindle 1: Tool measurement with stationary spindle	PLC RUN	
MP6505	Probing direction for tool radius measurement for 3 traverse ranges Input: 0: Positive probing direction of the angle reference axis (0° axis) 1: Positive probing direction in the +90° axis 2: Negative probing direction of the angle reference axis (0° axis) 3: Negative probing direction in the +90° axis	PLC RUN CN123	8 – 197
MP6505.0	Traverse range 1		
MP6505.1	Traverse range 2		
MP6505.2	Traverse range 3		

MP	Function and input	Software version and behavior	Page
MP6507	Calculation of the probing feed rate Input: 0: Calculation of the probing feed rate with constant tolerance 1: Calculation of the probing feed rate with variable tolerance 2: Constant probing feed rate	PLC RUN CN123	8 – 200
MP6510 MP6510.0 MP6510.1	Permissible measuring error for tool measurement with rotating tool Input: 0.002 to 0.999 [mm] First measurement error Second measurement error	PLC RUN CN123	8 – 201
MP6520	Probing feed rate for tool measurement with non-rotating tool Input: 1 to 3000 [mm/min]	PLC RUN CN123	8 – 200
MP6530 MP6530.0 MP6530.1 MP6530.2	Distance from the tool end to the top of the probe contact during tool radius measurement for 3 traverse ranges Input: 0.001 to 99.9999 [mm] Traverse range 1 Traverse range 2 Traverse range 3	PLC RUN CN123	8 – 197
MP6531 MP6531.0 MP6531.1 MP6531.2	Diameter or edge length of the TT 130 probe contact for 3 traverse ranges Input: 0.001 to 99.9999 [mm] Traverse range 1 Traverse range 2 Traverse range 3	PLC RUN	8 – 198
MP6540 MP6540.0 MP6540.1	Safety zone around the probe contact of the TT 130 for pre-positioning Input: 0.001 to 99 999.9999 [mm] Safety clearance in tool axis direction Safety clearance in the plane perpendicular to the tool axis	PLC RUN CN123	8 – 197
MP6550	Rapid traverse in probing cycle for TT 130 Input: 10 to 300 000 [mm/min]	PLC RUN CN123	8 – 197
MP6560	M function for spindle orientation during individual tooth measurement Input: –1: Spindle orientation directly by NC 0: Function inactive 1 to 999: Number of the M function for spindle orientation by PLC	PLC RUN CN123	8 – 196

MP	Function and input	Software version and behavior	Page
MP6570	Max. permissible surface cutting speed at the tooth edge Input: 1.0000 to 129.0000 [m/min]	PLC RUN CN123	8 – 200
MP6572	Maximum permissible speed during tool measurement Input: 1 to 1000 [rpm] 0: 1000 [rpm]	PLC RUN CN123	8 – 200
MP6580.0-2	Coordinates of the TT 130 probe contact center with respect to the machine datum (traverse range 1) Input: –99 999.9999 to +99 999.9999 [mm]	PLC RUN CN123	8 – 198
MP6581.0-2	Coordinates of the TT 130 probe contact center with respect to the machine datum (traverse range 2) Input: –99 999.9999 to +99 999.9999 [mm]	PLC RUN CN123	8 – 198
MP6582.0-2	Coordinates of the TT 130 probe contact center with respect to the machine datum (traverse range 3) Input: –99 999.9999 to +99 999.9999 [mm]	PLC RUN CN123	8 – 198
MP6585	Monitoring the position of the rotary and additional linear axes during the tool measurement cycles Format: %xxxxxx Input: 0: Axis is not monitored 1: Axis is monitored Bit 0 – A axis Bit 1 – B axis Bit 2 – C axis Bit 3 – U axis Bit 4 – V axis Bit 5 – W axis	PLC RUN CN123	8 – 201
MP6586	Ref. coordinate for monitoring the position of the rotary and additional linear axes during the tool measurement cycles Input: –99 999.9999 to +99 999.9999 [mm or °]	PLC RUN CN123	8 – 201
MP6586.0	A axis		
MP6586.1	B axis		
MP6586.2	C axis		
MP6586.3	U axis		
MP6586.4	V axis		
MP6586.5	W axis		

4.4.11 Tapping

MP	Function and input	Software version and behavior	Page
MP7110.0	Minimum for feed-rate override during tapping Input: 0 to 150 [%]	PLC RUN	6 – 215
MP7110.1	Maximum for feed-rate override during tapping Input: 0 to 150 [%]		
MP7120.0	Dwell time for reversal of spindle rotational direction Input: 0 to 65.535 [s]	PLC RUN	6 – 215, 6 – 216
MP7120.1	Advanced switching time of the spindle during tapping with coded spindle-speed output Input: 0 to 65.535 [s]		
MP7120.2	Spindle slow-down time after reaching the hole depth Input: 0 to 65.535 [s]		
MP7130	Run-in behavior of the spindle during rigid tapping Input: 0.001 to 10 [°/min]	PLC RUN	6 – 219
MP7150	Positioning window of the tool axis during rigid tapping Input: 0.0001 to 2 [mm]	PLC RUN	6 – 219
MP7160	Spindle response during Cycles 17, 207 and 18 Format: %xxxxx Input: Bit 0 – Oriented spindle stop with Cycles 17 and 207 0: Oriented spindle stop before execution of the cycle 1: No oriented spindle stop before execution of the cycle Bit 1 – Spindle speed 0: Spindle speed is not limited 1: Spindle speed is limited so that it runs with constant speed approx. 1/3 of the time Bit 2 – Spindle in position feedback control 0: Spindle operated without position feedback control 1: Spindle operated with position feedback control Bit 3 – Acceleration feedforward control 0: Active 1: Not active Bit 4 – 0: Tool axis tracks the spindle 1: Tool axis and spindle interpolated	PLC RUN CN123	6 – 219

4.4.12 Display and Operation

MP	Function and input	Software version and behavior	Page
MP7210	Programming station Input: 0: Controlling and programming 1: Programming station with PLC active 2: Programming station with PLC inactive	CN123	8 – 60
MP7212	Power interrupted message Input: 0: Acknowledge the **Power interrupted** message with CE key 1: **Power Interrupted** message does not appear	PLC RUN CN123	8 – 58
MP7220	Block number increment for ISO programs Input: 0 to 250	PLC RUN CN123	8 – 35
MP7224	File types, disabling Input: 0: Do not disable 1: Disable Bit 0 – HEIDENHAIN programs *.H Bit 1 – ISO programs *.I Bit 2 – Tool tables *.T Bit 3 – Datum tables *.D Bit 4 – Pallet tables *.P Bit 5 – Text files *.A Bit 6 – HELP files *.HLP Bit 7 – Point tables *.PNT	PLC RUN CN123	8 – 126
MP7224.0	Disabling soft keys for file types		
MP7224.1	Protecting file types		
MP7224.2	Disable the EDIT ON/OFF soft key	340 422-07, 340 480-07	
MP7225	Disable Windows drives in the TNC file manager Format: ABCDEFGHIJKLMNOPQRSTUVWXYZ Input: If there are more than one drive, they are entered without spaces, e.g. MP7225 = CDE	340 480-06 PLC RUN	–
MP7226.0	Reserved	PLC	
MP7226.1	Size of the datum table Input: 0 to 255 [lines]	RUN CN123	8 – 128
MP7229	Depiction of the NC program	PLC	8 – 36
MP7229.0	Line number for program testing Input: 100 to 9999	RUN CN123	
MP7229.1	Program length to which FK blocks are allowed Input: 100 to 9999		

MP	Function and input	Software version and behavior	Page
MP7230	Switching the conversational language Input: 0: English 1: German 2: Czech 3: French 4: Italian 5: Spanish 6: Portuguese 7: Swedish 8: Danish 9: Finnish 10: Dutch 11: Polish 12: Hungarian 13: Reserved 14: Russian (Cyrillic characters) 15: Chinese (simplified) 16: Chinese (traditional) 14, 15 and 16 only with the MC 422B and BF 150	PLC RUN CN123	8 – 74
MP7230.0	NC conversational language, soft keys for OEM cycles		
MP7230.1	PLC conversational language (user parameters)		
MP7230.2	PLC error messages		
MP7230.3	Help files		
MP7235	Time difference to Universal Time (Greenwich Mean Time) Input: –23 to +23 [hours]	Only until 340 480-03 RESET CN123	8 – 20

MP	Function and input	Software version and behavior	Page
MP7237	Display and reset the operating times	PLC	8 – 17
MP7237.0	Display PLC operating times Input: Bits 0 to 12 represent PLC operating times 1 to 13 0: Do not display 1: Display	RUN	
MP7237.1	Resetting PLC operating times with the code number 857282 Input: Bits 0 to 12 represent PLC operating times 1 to 13 0: Do not reset 1: Reset		
MP7237.2	Reset NC operating times with the code number 857282 Input: Bit 0 – No function Bit 1 – "Machine on" operating time Bit 2 – "Program run" operating time 0: Do not reset 1: Reset		
MP7238.0-12	Dialog messages for PLC operating times 1 to 13 Input: 0 to 4095 Dialog no. from the file (OEM.SYS)	PLC RUN	8 – 17
MP7245	Disabling auxiliary cycles Input: 0: Auxiliary cycles disabled 1: Auxiliary cycles permitted	PLC RUN	8 – 54
MP7246	Machine parameter with multiple function Input: %xxx Bit 0 – Paraxial positioning blocks 0: Permitted 1: Locked Bit 1 – Clear with DEL key 0: Does not need confirmation 1: Must confirm via soft key Bit 2 – Tool usage file 0: Do not generate 1: Generate	PLC RUN	8 – 35, 8 – 58, 8 – 232
MP7251	Number of global Q parameters starting from Q99 (up to Q60) that are transferred from the OEM cycle to the calling program. Input: 0 to 40	PLC RUN	9 – 28
MP7260	Number of tools in the tool table Input: 0 to 30 000	CN123	8 – 209
MP7261.0-3	Number of pockets in the tool magazine 1 to 4 Input: 0 to 254	CN123	8 – 209
MP7262	Maximum tool index number for indexed tools Input: 0 to 9	CN123	8 – 231

MP	Function and input	Software version and behavior	Page
MP7263	Pocket table Format: %xx Input: Bit 0 – 0: Show POCKET TABLE soft key 1: Hide POCKET TABLE soft key Bit 1 – Output of the columns for file functions 0: Output only the displayed columns 1: Output all columns	CN123	8 – 209

MP	Function and input	Software version and behavior	Page
MP7266	Elements of the tool table Input: 0: No display 1 to 99: Position in the tool table	CN123	8 – 209
MP7266.0	16-character alphanumeric tool name (NAME)		
MP7266.1	Tool length (L)		
MP7266.2	Tool radius (R)		
MP7266.3	Tool radius 2 for toroidal cutter (R2)		
MP7266.4	Oversize in tool length (DL)		
MP7266.5	Oversize in tool radius (DR)		
MP7266.6	Oversize for tool radius 2 (DR2)		
MP7266.7	Locked tool? (TL)		
MP7266.8	Replacement tool (RT)		
MP7266.9	Maximum tool age, M4543 (TIME1)		
MP7266.10	Maximum tool age, TOOL CALL (TIME2)		
MP7266.11	Current tool age (CUR.TIME)		
MP7266.12	Comment on the tool (DOC)		
MP7266.13	Number of tool teeth (CUT)		
MP7266.14	Wear tolerance for tool length (LTOL)		
MP7266.15	Wear tolerance for tool radius (RTOL)		
MP7266.16	Cutting direction of the tool (DIRECT)		
MP7266.17	Additional information for PLC, Module 9093 (PLC)		
MP7266.18	Tool offset for tool length (TT:LOFFS)		
MP7266.19	Tool offset for tool radius (TT:ROFFS)		
MP7266.20	Breakage tolerance for tool length (LBREAK)		
MP7266.21	Breakage tolerance for tool radius (RBREAK)		
MP7266.22	Tooth length (LCUTS)		
MP7266.23	Plunge angle (ANGLE)		
MP7266.24	Tool type (TYP)		
MP7266.25	Tool material (TMA)		
MP7266.26	Cutting-data tables (CDT)		
MP7266.27	PLC value (PLC-VAL)		
MP7266.28	Probe center offset in reference axis (CAL-OF1)		
MP7266.29	Probe center offset in minor axis (CAL-OF2)		
MP7266.30	Spindle angle during calibration (CAL-ANG)		
MP7266.31	Tool type for pocket table (PTYP)	340 420-02	
MP7266.32	Maximum shaft speed [rpm] (NMAX)	340 422-03, 340 480-03	
MP7266.33	Retract tool (LIFTOFF)	340 422-06, 340 480-06	

MP	Function and input	Software version and behavior	Page
MP7267	Elements of the pocket table Input: 0: No display 1 to 99: Position in the pocket table	CN123	8 – 210
MP7267.0	Tool number (T)		
MP7267.1	Special tool (ST)		
MP7267.2	Fixed pocket (F)		
MP7267.3	Locked pocket (L)		
MP7267.4	PLC status (PLC)		
MP7267.5	Tool name (TNAME)		
MP7267.6	Comment on the tool (DOC)		
MP7267.7	Tool type for pocket table (PTYP)	340 420-02	
MP7267.8	Value 1 (P1)		
MP7267.9	Value 2 (P2)		
MP7267.10	Value 3 (P3)		
MP7267.11	Value 4 (P4)		
MP7267.12	Value 5 (P5)		
MP7267.13	Reserve pocket (RSV)		
MP7267.14	Pocket above locked (LOCKED_ABOVE)		
MP7267.15	Pocket below locked (LOCKED_BELOW)		
MP7267.16	Pocket at left locked (LOCKED_LEFT)		
MP7267.17	Pocket at right locked (LOCKED_RIGHT)		
MP7270	Feed rate display in the operating modes MANUAL OPERATION and ELECTRONIC HANDWHEEL Input: 0: Display of axis feed rate through pressing an axis direction key (axis-specific feed rate from MP1020) 1: Display of axis feed rate also before an axis direction key is pressed (smallest value from MP1020 for all axes)	PLC RUN CN123	8 – 8
MP7280	Decimal character Input: 0: Decimal comma 1: Decimal period	PLC RUN CN123	8 – 74
MP7281	Depiction of the NC program Input: 0: All blocks completely 1: Current block completely, others line by line 2: All blocks line by line; complete block when editing	PLC RUN CN123	8 – 35
MP7285	Tool length offset in the tool-axis position display Input: 0: Tool length is not offset 1: Tool length is offset	PLC RUN CN123	8 – 4

MP	Function and input	Software version and behavior	Page
MP7289	Position display step for the spindle Input: 0: 0.1° 1: 0.05° 2: 0.01° 3: 0.005° 4: 0.001° 5: 0.0005° 6: 0.0001°	PLC RUN CN123	8 – 3
MP7290.0-8	Position display step for axes 1 to 9 Input 0: 0.1 mm or 0.1° 1: 0.00 in or 0.05° 2: 0.00 in or 0.01° 3: 0.000 in or 0.005° 4: 0.000 in or 0.001° 5: 0.0000 in or 0.0005° 6: 0.0001 mm or 0.0001°	PLC RUN CN123	8 – 3
MP7291	Display of axes on the screen Format: SXYZABCUVWxyzabcuvw- Input: Characters 1 to 9 from the right represent lines 1 to 9 Character 10 is spindle S which is always output in line 10.	PLC RUN	6 – 3
MP7291.0	Display in traverse range 1		
MP7291.1	Display in traverse range 2		
MP7291.2	Display in traverse range 3		
MP7294	Disable axis-specific “Datum setting” in the preset table Format: %xxxxxxxxxxxxxx Input: Bits 0 to 13 represent axes 1 to 14 0: Not disabled 1: Disabled	340 422-01, 340 480-02 PLC RUN CN123	8 – 34
MP7295	Disable “Datum setting” Format: %xxxxxxxxxxxxxx Input: Bits 0 to 13 represent axes 1 to 14 0: Not disabled 1: Disabled	PLC RUN CN123	8 – 33
MP7296	“Datum setting” through axis keys Input: 0: Datum can be set by axis keys and soft key 1: Datum can be set only by soft key	PLC RUN CN123	8 – 33

MP	Function and input	Software version and behavior	Page
MP7300	Erasing the status display and Q parameters Input: 0: Erase the status display, Q parameters and tool data when a program is selected. 1: Erase the status display, Q parameters and tool data if a program is selected and in the event of M02, M30, and END PGM. 2: Erase the status display and tool data if a program is selected. 3: Erase the status display and tool data if a program is selected and in the event of M02, M30, END PGM. 4: Erase the status display and Q parameters if a program is selected. 5: Erase the status display and Q parameters if a program is selected and in the event of M02, M30, END PGM. 6: Erase the status display if a program is selected and in the event of M02, M30, END PGM. 7: Erase the status display if a program is selected and in the event of M02, M30, END PGM.	PLC RUN CN123	8 – 12
MP7310	Graphic display mode Format: %xxxxxxxx Input: Bit 0 – Projection in three planes: 0: German-preferred projection 1: US-preferred projection Bit 1 – Rotating the coordinate system in the working plane by 90°: 0: No rotation 1: Rotation by +90° Bit 2 – BLK form after datum shift: 0: Shifted 1: Not shifted Bit 3 – Display of the cursor position: 0: Not displayed 1: Displayed Bit 4 – Reserved Bit 5 – Reserved Bit 6 – Reserved Bit 7 – Reserved	PLC RUN CN123	8 – 67
MP7315	Tool radius for graphic simulation without TOOL CALL Input: 0.0000 to 99 999.9999 [mm]	PLC RUN CN123	8 – 206
MP7316	Penetration depth of the tool Input: 0.0000 to 99 999.9999 [mm]	PLC RUN CN123	8 – 206

MP	Function and input	Software version and behavior	Page
MP7317 MP7317.0 MP7317.1	M function for graphic simulation Beginning of graphic simulation Input: 0 to 88 Interruption of the graphic simulation Input: 0 to 88	PLC RUN CN123	8 – 206
MP7330.0-15	Specifying the user parameters 1 to 16 Input: 0 to 9999.00 (no. of the user parameter)	PLC RUN	8 – 59
MP7340.0-15	Dialog messages for user parameters 1 to 16 Input: 0 to 4095 (line number of the PLC dialog message file)	PLC RUN	8 – 59

4.4.13 Colors

MP	Function and input	Software version and behavior	Page
MP7350	Window frames	PLC RUN	8 – 61
MP7351 MP7351.0 MP7351.1 MP7351.2	Error messages Priority 0 (error) Priority 1 (warning) Priority 2 (information)	340 422-06, 340 480-06 PLC RUN	8 – 61
MP7352 MP7352.0 MP7352.1 MP7352.2	“Machine” operating mode display Background Text for operating mode Dialog	PLC RUN	8 – 61
MP7353 MP7353.0 MP7353.1 MP7353.2	“Programming” operating mode display Background Text for operating mode Dialog	PLC RUN	8 – 61
MP7354 MP7354.0 MP7354.1 MP7354.2 MP7354.3	“Machine” program text display Background General program text Active block Background, not current window, comments, and unused machine parameters in the machine parameter file	PLC RUN	8 – 62
MP7355 MP7355.0 MP7355.1 MP7355.2 MP7355.3	“Programming” program text display Background General program text Active block Background, not current window, comments, and unused machine parameters in the machine parameter file	PLC RUN	8 – 62
MP7356 MP7356.0 MP7356.1 MP7356.2	Status window and PLC window Background Axis positions in the status display Status display other than axis positions	PLC RUN	8 – 62
MP7357 MP7357.0 MP7357.1 MP7357.2 MP7357.3	“Machine” soft-key display Background Text color Inactive soft-key row Active soft-key row	PLC RUN	8 – 62

MP	Function and input	Software version and behavior	Page
MP7358	"Programming" soft-key display	PLC	8 – 62
MP7358.0	Background	RUN	
MP7358.1	Text color		
MP7358.2	Inactive soft-key row		
MP7358.3	Active soft-key row		
MP7360	Graphics: 3-D view and plan view	PLC	8 – 62
MP7360.0	Background	RUN	
MP7360.1	Top surface		
MP7360.2	3-D: Front face		
MP7360.3	Text display in the graphics window		
MP7360.4	3-D: Lateral face		
MP7360.5	Lowest point of blank form		
MP7360.6	Highest point of blank form (below surface)		
MP7361	Graphics: Projection in three planes	PLC	8 – 62
MP7361.0	Background	RUN	
MP7361.1	Top view		
MP7361.2	Front and side view		
MP7361.3	Axis cross and text in the graphic display		
MP7361.4	Cursor		
MP7362	Additional status display in the graphics window	PLC	8 – 62
MP7362.0	Background of graphic window	RUN	
MP7362.1	Background of status display		
MP7362.2	Status symbols		
MP7362.3	Status values		
MP7363	Programming graphics	PLC	8 – 62
MP7363.0	Background	RUN	
MP7363.1	Resolved contour		
MP7363.2	Subprograms and frame for zooming		
MP7363.3	Alternative solutions		
MP7363.4	Unresolved contour		
MP7363.5	Rapid traverse movements		
MP7364	Color of the help illustrations for cycles	PLC	8 – 63
MP7364.0-6	Colors 1 to 7 of the graphic program used	RUN	
MP7364.7	Line color (color 8 of the graphic program)		
MP7364.8	Color for highlighted graphic elements if defined in the help illustration		
MP7364.9	Background		

MP	Function and input	Software version and behavior	Page
MP7365 MP7365.0 MP7365.1 MP7365.2 MP7365.3 MP7365.4-9	Oscilloscope Background Grid Cursor and text Selected channel Channel 1 to 6	340 420-02 PLC RUN	8 – 63
MP7366 MP7366.0 MP7366.1 MP7366.2 MP7366.3 MP7366.4 MP7366.5 MP7366.6-14	Pop-up window (HELP key, pop-up menus etc.) Background Text or foreground Active line Title bar Scroll-bar field Scroll bar Reserved	PLC RUN	8 – 63
MP7367 MP7367.0 MP7367.1-7 MP7367.8-14	Large PLC window Background Colors 1 to 7 (Color 8: MP7350) Colors 9 to 15	PLC RUN	8 – 63
MP7368 MP7368.0 MP7368.1 MP7368.2 MP7368.3	Pocket calculator Background Background of displays and keys Key texts (“os” in “cos”) Key symbols	PLC RUN	8 – 63
MP7369 MP7369.0 MP7369.1 MP7369.2 MP7369.3 MP7369.4 MP7369.5 MP7369.6	Directory tree in PGM MGT Text background Text Text background of the active folder Line color of the tree structure Folders Drives Text background of the heading in the browser window	PLC RUN	8 – 63
MP7370 MP7370.0 MP7370.1-15	Small PLC window Background Colors 1 to 15	340 420-05 PLC RUN	8 – 63
MP7392	Screen saver Input: 1 to 99 [min] 0: No screen saver	PLC RUN CN123	8 – 63

4.4.14 Machining and Program Run

MP	Function and input	Software version and behavior	Page
MP7410	Scaling cycle in two or three axes Input: 0: Scaling cycle is effective in all three principal axes 1: Scaling cycle is effective only in the working plane	PLC RUN CN123	8 – 41
MP7411	Tool data in the touch probe block Format: %xx Input: Bit 0 – 0: Use the calibrated data of the touch probe 1: Use the current tool data from the last TOOL CALL Bit 1 – 0: Only one set of touch probe calibration data 1: Use the tool table to manage more than one set of touch probe calibration data	PLC RUN CN123	8 – 185
MP7420	Cycles for milling pockets with combined contours Format: %xxxxx Input: Bit 0 – Milling direction for channel milling: 0: Counterclockwise for pockets, clockwise for islands 1: Clockwise for pockets, counterclockwise for islands Bit 1 – Sequence for rough-out and channel milling (only for SL 1): 0: First channel milling, then pocket rough-out 1: First pocket rough-out, then channel milling Bit 2 – Merging of listed contours: 0: Contours are merged only if the tool-center paths intersect 1: Contours are merged if the programmed contours intersect Bit 3 – Rough-out and channel milling to pocket depth or for every infeed 0: Each process uninterrupted to pocket depth 1: Both processes for each pecking depth before proceeding to the next depth Bit 4 – Position after completion of the cycle: 0: Tool moves to the same position as before the cycle was called 1: Tool only moves in the tool axis to the "clearance height"	PLC RUN CN123	8 – 41
MP7430	Overlap factor for pocket milling Input: 0.001 to 1.414	PLC RUN CN123	8 – 39

MP	Function and input	Software version and behavior	Page
MP7431	Arc end-point tolerance Input: 0.0001 to 0.016 [mm]	PLC RUN CN123	8 – 58
MP7440	Output of M functions Format: %xxxxxxx Input: Bit 0 – Program stop with M06 0: Program stop with M06 1: No program stop with M06 Bit 1 – Modal cycle call M89 0: Normal code transfer of M89 at beginning of block 1: Modal cycle call M89 at end of block Bit 2 – Program stop with M functions: 0: Program stop until acknowledgment of the M function 1: No program stop: No waiting for acknowledgment. Bit 3 – Switching of k_V factors with M105/M106: 0: Function is not in effect 1: Function is effective Bit 4 – Reduced feed rate in the tool axis with M103: 0: Function is not in effect 1: Function is effective Bit 5 – Reserved Bit 6 – Automatic activation of M134 0: M134 must be activated in the NC program 1: M134 is automatically activated when an NC program is selected.	PLC RUN CN123	6 – 45, 6 – 85, 6 – 129, 6 – 131, 8 – 53, 8 – 207
MP7441	Error message during cycle call Format: %xxx Input: Bit 0 – 0: Error message **Spindle ?** is not suppressed 1: Error message **Spindle ?** is suppressed Bit 1: Reserved, enter 0 Bit 2 – 0: Error message **Enter depth as negative** is suppressed 1: Error message **Enter depth as negative** is not suppressed	PLC RUN CN123	8 – 53
MP7442	Number of the M function for spindle orientation in the cycles Input: 1 to 999: Number of the M function 0: No oriented spindle stop –1: Oriented spindle stop by the NC	PLC RUN CN123	6 – 209

MP	Function and input	Software version and behavior	Page
MP7450	Offsetting the tool change position from MP951.x in block scan Format: %xxxxxxxxxxxxxx Input: Bits 0 to 3 represent axes 1 to 14: 0: Do not offset 1: Offset	PLC RUN	8 – 43
MP7460.x	Reserved	340 422-10, 340 480-10 PLC RUN CN123	–
MP7461.x	Reserved	340 422-10, 340 480-10 PLC RUN CN123	–
MP7451.0-8	Feed rate for returning to the contour for axes 1 to 9 Input: 10 to 300 000 [mm/min]	PLC RUN	8 – 43
MP7470	Maximum contouring tool feed rate at 100% override Input: 0 to 300 000 [mm/min] 0: No limitation	PLC RUN CN123	–
MP7471	Maximum velocity of the principal axes during compensating movements through M128 or TCPM Input: 0 to 300 000 [mm/min]	PLC RUN CN123	6 – 85
MP7475	Reference for datum table Input: 0: Reference is workpiece datum 1: Reference is machine datum (MP960.x)	PLC RUN CN123	8 – 128

MP	Function and input	Software version and behavior	Page
MP7480	Output of the tool or pocket number	PLC	8 – 242
MP7480.0	With TOOL CALL block	RUN	
	Input: 0: No output 1: Tool number output only when tool number changes 2: Tool number output for every TOOL CALL block 3: Output of the pocket number and tool number only when tool number changes 4: Output of the pocket number and tool number for every TOOL CALL block 5: Output of the pocket number and tool number only when tool number changes. Pocket table is not changed. 6: Output of the pocket number and tool number for every TOOL CALL block. Pocket table is not changed.		
MP7480.1	With TOOL DEF block		
	Input: 0: No output 1: Tool number output only when tool number changes 2: Output of tool number for every TOOL DEF block 3: Output of the pocket number and tool number only when tool number changes 4: Output of pocket number and tool number for every TOOL DEF block		
MP7481.x	Sequence for new and returned tool when changing tools	340 420-06	8 – 245
	Format: %xxxx 0: First, output the pocket of the tool to be returned 1: First, output the pocket of the new tool Input: Bit 0: New tool from magazine 1 Bit 1: New tool from magazine 2 Bit 2: New tool from magazine 3 Bit 2: New tool from magazine 4	PLC RUN	
MP7481.0	Tool from magazine 1 to be returned		
MP7481.1	Tool from magazine 2 to be returned		
MP7481.2	Tool from magazine 3 to be returned		
MP7481.3	Tool from magazine 4 to be returned		
MP7482	Pocket coding of the tool magazine	340 420-06	8 – 242
	Format: %xxxx 0: Variable pocket coding 1: Fixed pocket coding Input: Bit 0: Magazine 1 Bit 1: Magazine 2 Bit 2: Magazine 3 Bit 3: Magazine 4	PLC RUN	

MP	Function and input	Software version and behavior	Page
MP7490	Functions for traverse ranges Format: %xxxx Input: Bit 0 – 0: Display one traverse range with MOD 1: Display three traverse ranges with MOD Bit 1 – 0: Each traverse range has its own datum (and 3 memories for the positions of the swivel head) 1: One datum for all traverse ranges Bit 2 – Calibration data: touch probe for workpiece measurement: 0: One set of calibration data for all traverse ranges 1: Every traverse range has its own set of calibration data Bit 3 – Calibration data: touch probe for tool measurement: 0: One set of calibration data for all traverse ranges 1: Every traverse range has its own set of calibration data	PLC RUN	6 – 23, 8 – 185, 8 – 195
MP7492.x MP7492.0 MP7492.13	Number of axis in which the same datum is to be set during Datum Setting (with active preset table) Input: 0 to 9 –1: Do not set a datum Datum set in the first axis to Datum set in the 14th axis	340 422-03, 340 480-03 PLC RUN	8 – 33
MP7494	Axes for which an exact stop is to occur after positioning Format: %xxxxxxxxxxxxxx Input: Bits 0 to 13 correspond to axes 1 to 14 0: No exact stop 1: Exact stop	340 422-06, 340 480-06 PLC RUN	–

MP	Function and input	Software version and behavior	Page
MP7500	Tilt working plane (inactive preset table) Format: %xxxxxxxxx Input: Bit 0 – "Tilted working plane" 0: Off 1: On Bit 1 – 0: Angles correspond to the position of the tilting axes of the head/table 1: Angles correspond to the spatial angle (the iTNC calculates the position of the tilted axes of the head/table) Bit 2 – 0: The tilting axes are not positioned with Cycle 19 1: The tilting axes are positioned with Cycle 19 Bit 3 – 0: The current tilting-axis position is taken into account with respect to the machine datum 1: The 0° position is assumed for the first rotary axis Bit 4 – 0: Compensate mechanical offset during exchange of the spindle head when calling M128, M114, TCPM or "tilted working plane" 1: Compensate mechanical offset during PLC datum shift Bit 5 – 0: The current tilting-axis position is taken into account with respect to the machine datum 1: The tilting-axis position that was entered with the 3-D ROT soft key applies. Bit 6 – 0: Spatial angle C is realized through a rotation of the coordinate system. 1: Spatial angle C is realized through a rotation of the table. Bit 7 – 0: The current tilting-axis position is taken into account with respect to the machine datum 1: The active tilting-axis position is a) derived from the tilting angles in the 3D ROT window if manual tilting is active b) derived from the reference coordinates of the rotary axes if tilting is inactive Bit 8 – 0: The tilting axis positioning is considered depending on bit 3, bit 5 and bit 7 1: If manual tilting is active, the datum to be set for the principal axes X, Y and Z is recalculated back to the home position of the tilting element	PLC RUN	6 – 81

MP	Function and input	Software version and behavior	Page
MP7500	Tilt working plane (active preset table) Format: %xxxxxxxxx Input: Bit 0 – "Tilted working plane" 0: Off 1: On Bit 1 – 0: Angles correspond to the position of the tilting axes of the head/table 1: Angles correspond to the spatial angle (the iTNC calculates the position of the tilted axes of the head/table) Bit 2 – 0: The tilting axes are not positioned with Cycle 19 1: The tilting axes are positioned with Cycle 19 Bit 3 – No function Bit 4 – No function Bit 5 – Test of the tilting axis during "datum setting" in X, Y and Z 0: Current tilting-axis position must fit to the defined tilting angles 1: No test Bit 6 – 0: Spatial angle C is realized through a rotation of the coordinate system. 1: Spatial angle C is realized through a rotation of the table. Bit 7 – No function Bit 8 – No function Bit 9 – Reserved	340 422-01, 340 480-02 PLC RUN	6 – 82
MP7502	Functionality of M144/M145 Input: %xxx Bit 0 – 0: M144/M145 not active 1: M144/M145 active Bit 1 – M144/M145 in the automatic modes 0: M144/M145 active 1: M144 is activated automatically at the start of an NC program. It can only be deactivated with M145 during an NC program. Bit 2 – M144/M145 in the manual modes 0: M144/M145 not active 1: M144/M145 active	PLC RUN	6 – 86

MP	Function and input	Software version and behavior	Page
MP7510	Transformed axis	PLC	6 – 82
	Format: %xxxxxx Input: 0: End of the transformation sequence Bit 0 corresponds to axis X Bit 1 corresponds to axis Y Bit 2 corresponds to axis Z Bit 3 corresponds to axis A Bit 4 corresponds to axis B Bit 5 corresponds to axis C	RUN	
MP7510.0-14	Transformation 1 to transformation 15		
MP7520	Additional code for transformation	PLC	6 – 82
	Format: %xx Input: Bit 0 – Tilting axis 0: Swivel head 1: Tilting table Bit 1 – Type of dimension in MP7530 0: Incremental dimension for swivel head 1: Absolute with respect to the machine datum for tilting table	RUN	
MP7520.0-14	Transformation 1 to transformation 15		
MP7530	Type of dimension for transformation	PLC	6 – 83
	Input: –99 999.9999 to +99 999.9999 0: Free tilting axis	RUN	
MP7530.0-14	Transformation 1 to transformation 15		
MP7550	Home position of the tilting element	PLC	6 – 83
	Input: –99 999.9999 to +99 999.9999	RUN	
MP7550.0	A axis		
MP7550.1	B axis		
MP7550.2	C axis		

4.4.15 Hardware

MP	Function and input	Software version and behavior	Page
MP7600.0	Only CC 422: Position controller cycle time = MP7600.0 · 0.6 ms Input: 1 to 20 Proposed input value: 3 (= 1.8 ms) Proposed input value for basic version: 6 (= 3.6 ms)	RESET	6 – 127
MP7600.1	Only CC 422: PLC cycle time = MP7600.1 ·Position controller cycle time = MP7600.0 · MP7600.1 · 0.6 ms Input: 1 to 20 Proposed input value: 6 (= 10.8 ms) Proposed input value for basic version: 3 (= 10.8 ms)		6 – 127, 9 – 3
MP7602	Only CC 424: PLC cycle time Input: 0 to 60 [ms] 0 to 10: 10.8 ms	340 422-03, 340 480-03	7 – 9
MP7620	Feed-rate override and spindle speed override Format: %xxxxxxx Input: Bit 0 – Feed-rate override if rapid traverse key is pressed in **Program Run** mode. 0: Override not effective 1: Override effective Bit 1 – No function Bit 2 – Feed-rate override if rapid traverse key and machine direction button are pressed in **Manual mode** 0: Override not effective 1: Override effective Bit 3 – Feed-rate override and spindle speed override in 1% increments or according to a nonlinear characteristic curve 0: 1% steps 1: Nonlinear characteristic curve Bit 4 – No function Bit 5 – Reserved Bit 6 – Feed-rate smoothing 0: Not active 1: Active Bit 7 – Reserved	PLC RUN	6 – 125, 6 – 204, 8 – 8
MP7621	Reserved		–

MP	Function and input	Software version and behavior	Page
MP7640	Handwheel Input: 0: No handwheel 1: Reserved 2: HR 130 3: Reserved 4: Reserved 5: Up to three HR 150 via HRA 110 6: HR 410 7 to 10: Reserved 11: HR 420	PLC RUN	8 – 153
MP7641	Handwheel settings Format: %xxxxxxxxxxxxxx Input: Bit 0 – HR 410: Entry of interpolation factor 0: Through iTNC keyboard 1: Through PLC Module 9036 Bit 1 – HR 420: With detent positions 0: Without detent positions 1: With detent positions Bit 2 – HR 420: Axis direction keys and rapid traverse 0: Controlled by the NC 1: Controlled by the PLC Bit 3 – HR 420: NC Start / NC Stop 0: Controlled by the NC 1: Controlled by the PLC	PLC RUN	8 – 153

MP	Function and input	Software version and behavior	Page
MP7645	Initializing parameter for handwheel	PLC	8 – 156, 8 – 157
MP7645.0	Layout of the handwheel keypad for HR 410 Input: 0: Evaluation of the keys by NC, including LEDs 1: Evaluation of the keys by PLC	RUN	
MP7645.0	Assignment of a third handwheel via axis selector switch S2, when MP7645.2 = 0 Input: 0: Switch position 1 (at the left stop) 3rd handwheel axis Z Switch position 2 3rd handwheel axis IV Switch position 3 3rd handwheel axis V 1: Switch position 1 3rd handwheel axis X Switch position 2 3rd handwheel axis Y Switch position 3 3rd handwheel axis Z Switch position 4 3rd handwheel axis IV Switch position 5 3rd handwheel axis V 2: Switch position 3 3rd handwheel axis Z Switch position 4 3rd handwheel axis IV Switch position 5 3rd handwheel axis V		
MP7645.1	Fixed assignment of third handwheel if MP7645.2 = 1 Input: 1: Axis X 2: Axis Y 4: Axis Z 8: Axis IV (MP410.3) 16: Axis V (MP410.4)		
MP7645.2	Assignment of a third handwheel via axis selector switch or MP7645.1 Input: 0: Assignment by axis selection switch according to MP7645.0 1: Assignment by MP7645.1		
MP7645.3-7	No function		
MP7650	Handwheel counting direction for each axis Input: Bits 0 to 13 correspond to axes 1 to 14 0: Negative counting direction 1: Positive counting direction	PLC RUN	8 – 153

MP	Function and input	Software version and behavior	Page
MP7660	Threshold sensitivity for electronic handwheel Input: 0 to 65 535 [increments]	PLC RUN	8 – 153
MP7670 MP7670.0 MP7670.1 MP7670.2	Interpolation factor for handwheel Input: 0 to 10 Interpolation factor for low speed Interpolation factor for medium speed (only HR 410) Interpolation factor for high speed (only HR 410)	PLC RUN	8 – 153, 8 – 156
MP7672.x	Reserved	340 422-06, 340 480-06 PLC RUN	–
MP7671 MP7671.0 MP7671.1 MP7671.2	Handwheel feed rate in the Handwheel operating mode with HR 410 Input: 0 to 1000 [% of MP1020] Low speed Medium speed (only HR 410) High speed (only HR 410)	PLC RUN	8 – 156

MP	Function and input	Software version and behavior	Page
MP7680	Machine parameter with multiple function Format: %xxxxxxxxxxxxxxx Input: Bit 0 – Memory function for axis-direction keys with M4562: 0: Not saved 1: Saved if M4562 is set Bit 1 – Returning to the contour 0: Not active 1: Active Bit 2 – Block scan 0: Not active 1: Active Bit 3 – Interruption of block scan for STOP or M06: 0: Interruption 1: No interruption Bit 4 – Inclusion of programmed dwell time during the block scan: 0: Include the dwell time 1: Do not include the dwell time Bit 5 – Start of calculation for block scan 0: Start from block with cursor 1: Start from beginning of program Bit 6 – Tool length in blocks with normal vectors: 0: Without R2 from tool table (south pole) 1: With R2 from tool table (center of sphere) Bit 7 – Inserting a defined rounding arc or spline: 0: Defined rounding arcs are always inserted 1: Defined rounding arcs are always inserted if the acceleration from MP1060.x or MP1070 was exceeded.	PLC RUN	6 – 168, 6 – 169, 8 – 38, 8 – 41, 8 – 43, 8 – 125, 8 – 230

MP	Function and input	Software version and behavior	Page
MP7680	Machine parameter with multiple function Bit 8 – Insertion of rounding arc or cubic spline 0: Rounding arc is inserted. 1: A cubic spline is inserted instead of a rounding arc. Bit 9 – Constant jerk on spline (bit 8 = 1) 0: No constant jerk 1: Constant jerk Bit 10 – Cutter-radius-compensated outside corners 0: Insertion of a circular arc 1: Insertion of a spline curve Bit 11 – Behavior of M116 0: Rotary axis is parallel to linear axis 1: Any position of rotary axis to linear axis Bit 12 – Behavior of Cycle 28 0: Standard behavior 1: The slot wall is approached and departed tangentially; at the beginning and end of the slot a rounding arc with a diameter equal to the slot width is cut Bit 13 – Behavior during program interruption with axis movement 0: Automatic activation of **APPROACH POSITION** 1: Do not automatically activate **APPROACH POSITION** Bit 14 – Behavior of NC start after NC stop and internal stop 0: NC start permitted 1: NC start only permitted after block scan GOTO Bit 15 – NC Start if program is aborted 0: NC start permitted 1: NC Start not permitted (message window)	PLC RUN	

MP	Function and input	Software version and behavior	Page
MP7681	M/S/T/Q transfer to the PLC during block scan Format: %xxxx Input: Bit 0 – 0: Transfer M functions to the PLC during block scan. 1: Collect M functions and transfer them to the PLC after block scan. Bit 1 – 0: Transfer T code to the PLC during block scan 1: Transfer last T code to the PLC after block scan Bit 2 – 0: Transfer S or G code to the PLC during block scan 1: Transfer S or G code to the PLC after block scan. Bit 3 – 0: Transfer FN19 outputs to the PLC during block scan 1: Transfer last FN19 outputs to the PLC after block scan.	PLC RUN	8 – 45
MP7682	Machine parameter with multiple function Format: %xxxxxxxx Input: Bit 0 – Incremental block after TOOL CALL 0: With length compensation 1: Without length compensation Bit 1 – Reference value for calculating the preset during datum setting 0: Actual value is calculated 1: Nominal value is calculated Bit 2 – Traverse path of rotary axes with modulo display 0: Positioning without passing over zero 1: Positioning on the shortest path Bit 3 – Reserved, enter 0 Bit 4 – Tolerance of rotary axes with M128 or TCPM 0: With consideration of head dimensions 1: Without consideration of head dimensions Bit 5 – Feed rate with M128 or TCPM 0: Feed rate refers to tool tip 1: Feed rate from interpolation of all axes involved Bit 6 – Exact stop with TOOL DEF 0: Active 1: Inactive Bit 7 – Block elements TOOL CALL and S in ISO blocks 0: Machine as programmed 1: Machine at beginning of block (block display does not change)	PLC RUN	6 – 83, 6 – 125, 8 – 4, 8 – 4, 8 – 38, 8 – 237

MP	Function and input	Software version and behavior	Page
MP7683	Executing pallet tables and NC programs Format: %xxxxx Input: Bit 0 – No function Bit 1 – **Program Run, Full Sequence** mode 0: During the start, a complete NC program is run. 1: At the start all NC programs are executed up to next pallet. Bit 2 – **Program Run, Full Sequence** mode 0: As defined in bit 1 1: All NC programs and pallets up to the end of the table are executed. Bit 3 – When the end of the table is reached, the process begins again with the first line. 0: Function is not in effect 1: Function is effective (bit 2=1) Bit 4 – Editing the active pallet table 0: Active pallet table cannot be edited. 1: In the **Program Run, Full Sequence** and **Program Run, Single Block** modes, the current pallet table can be edited. Bit 5 – AUTOSTART soft key 0: Do not display soft key 1: Display soft key Bit 6 – Display of pallet table and NC program 0: Both simultaneously in a split screen 1: Pallet table or NC program individually Bit 7 – AUTOSTART function 0: AUTOSTART function by NC 1: AUTOSTART function by PLC	PLC RUN	8 – 146, 8 – 37

MP	Function and input	Software version and behavior	Page
MP7684	Nominal position value filter (bit 0 to bit 4) and path control with M128 or TCPM (bit 5 to bit 7 permitted) Format: %xxxxxxxx Input: Bit 0 – Nominal position value filter 0: Include acceleration 1: Do not include the acceleration Bit 1 – Nominal position value filter 0: Include the jerk 1: Do not include the jerk Bit 2 – Nominal position value filter 0: Include the tolerance 1: Do not include the tolerance Bit 3 – Nominal position value filter 0: Include the radial acceleration 1: Do not include the radial acceleration Bit 4 – Nominal position value filter 0: Include curvature changes 1: Do not include curvature changes Bit 5 – Feed-rate reduction at corners with M128 or TCPM 0: Include only maximum compensatory path 1: Do not include compensatory paths Bit 6 – Feed-rate reduction at corners with M128 or TCPM 0: Include compensatory paths depending on the entry in bit 5 1: Include all compensatory paths Bit 7 – Reserved Bit 8 – Reserved	PLC RUN	6 – 85, 6 – 124
MP7690	Evaluation of the electronic ID labels Input: %xx Bit 0 – HEIDENHAIN power modules 0: Active 1: Inactive Bit 1 – HEIDENHAIN synchronous motors 0: Active 1: Inactive Bit 2 – Reserved	340 422-06, 340 480-06	–
MP7691	Size of a log file with operating system messages. Can only be evaluated by HEIDENHAIN. Set MP7691 = 0. Input: 0: Function inactive 1 to 10 [MB]	340 420-05	–

4.4.16 Second Spindle

MP	Function and input	Software version and behavior	Page
MP13010 to MP13520	Machine parameter block for the second spindle Input: Function and input range are identical with MP3010 to MP3520.		6 – 221

6 Configuring the Axes and Spindle

6.1 Control Loops

6.1.1 Selecting the Axes

With MP10 you define which machine axes are to be operable.
The bits may be changed during the run-time without a control reset. However, the bits to be changed must have been set before the control was switched on.
Changing bits that had not been set leads to a control reset.

MP10 **Active axes**
Format: %xxxxxxxxxxxxxx
Input: Bits 0 to 13 represent axes 1 to 14
0: Axis not active
1: Axis active

Screen display

You can define how the axes are shown on the screen:

- In MP100.x, assign a designation to each logical axis.
- Define in MP7291.x the screen line in which the axis is to be displayed.

Rules for the display:

- NC axes are designated with uppercase letters.
- PLC axes are designated with lowercase letters.
- Axes that are not present are given a hyphen "-".

MP100 **Designation of axes**
Format: -wvucbazyxWVUCBAZYX
Input: Characters 1 to 9 from the right represent axes 1 to 9
MP100.0 Designation of axes for traverse range 1
MP100.1 Designation of axes for traverse range 2
MP100.2 Designation of axes for traverse range 3

MP7291 **Display of axes on the screen**
Format: SXYZABCUVWxyzabcuvw-
Input: Characters 1 to 9 from the right represent lines 1 to 9
Character 10 is the spindle "S", which is always output in line 9.
MP7291.0 Display in traverse range 1
MP7291.1 Display in traverse range 2
MP7291.2 Display in traverse range 3

Assignment of axis keys IV and V

On the keyboard unit and the HR 410 handwheel, you can assign the axis keys IV and V as desired.

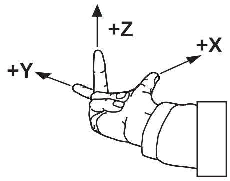
MP410 **Assignment of axis keys IV and V**
Input: Axis designation XYZABCUVWxyzabcuvw-
MP410.3 Axis key IV
MP410.4 Axis key V

6.1.2 Axis Designation

Principal axes X, Y, Z

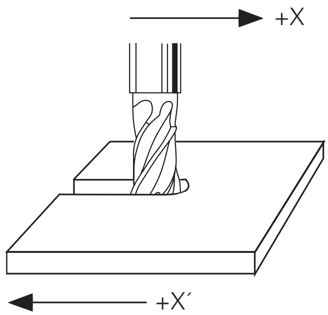
The coordinate axes and their directions of motion are defined in the international standard ISO 841.

An easy way to remember this system is to use the "right-hand rule":



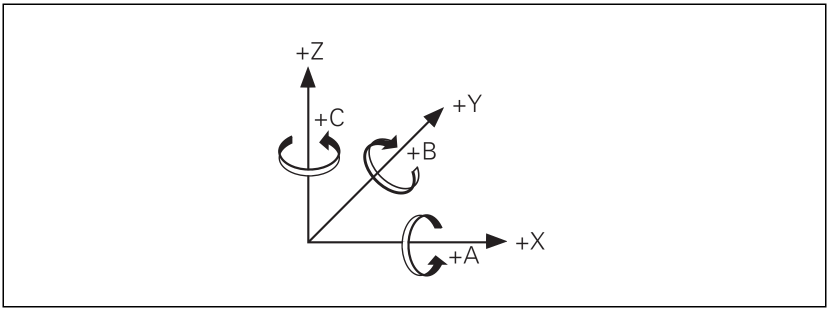
Algebraic signs of the axes

When the programmer writes an NC program, he always assumes that the tool (not the workpiece) is in motion. If the machine moves its workpiece-holding element (table) in a particular axis instead of the tool, then the direction of actual motion is opposite to the direction of axis motion. In this case the direction of motion is designated with the same algebraic sign as the axis direction, but with an apostrophe: +X´, +Y´ and +Z´:



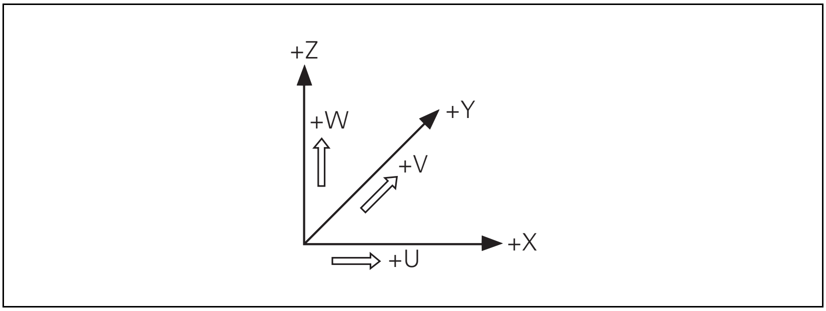
Rotary axes A, B, C

The directions of the rotary axes A, B and C follow the “right-fist rule.” The fingers of the closed right hand point in the proper rotational direction of an axis when the thumb points in the direction of the associated linear axis:



Secondary linear axes

The secondary linear axes U, V and W are parallel to the principal axes X, Y and Z.



6.1.3 Encoders

Position encoders report positions and movements of the machine to the control. The iTNC 530 operates with incremental and absolute encoders with EnDat interface.

Signal period

For any given distance the position encoder supplies a fixed number of signal periods. The signal is subdivided 1024 times.

To calculate the signal period, the control requires the following data:

- In MP331.x, enter for each axis the length required for the number of signal periods given in MP332.x.
- In MP332.x, enter for each axis the number of signal periods for the length given in MP331.x.

From this data the iTNC calculates the quotient:

$$\text{Signal period} = \frac{\text{MP331.x}}{\text{MP332.x}}$$

Note

Digital axes:
If no position encoder (MP110.x = 0) is connected, the data of the speed encoder must be entered in MP331.x and MP332.x. This also applies to speed encoders with EnDat interface, since the incremental track of the speed encoder is used for position feedback control.

HEIDENHAIN offers incremental linear encoders with **distance-coded reference marks.** The nominal increment between two fixed reference marks depends on the encoder being used:

- In MP334.x, enter for each axis the nominal increments between two fixed reference marks.

If the number of grating periods between the reference end position and the first reference mark exceeds the value from MP334.x, the error message `Ref mark <axis>: incorrect spacing` appears. This monitoring is turned off with MP334.x = 0.

Example:
LS 486C:
Incremental linear encoder with distance-coded reference marks, grating period 20 µm (= one signal period covers 0.02 mm), nominal increment between reference marks is 20 mm.

MP331.x = 0.02
MP332.x = 1

$$\text{MP334.x} = \frac{20\text{ mm}}{0.02\text{ mm}} = 1000 \text{ (or 0)}$$

MP331.x **Distance for the number of signal periods in MP332**
Input: 0.0001 to 99 999.9999 [mm] or [°]

MP332.x **Number of signal periods for the distance in MP331**
Input: 1 to 16 777 215

MP334.x **Nominal increment between two fixed reference marks on encoders with distance-coded reference marks**
Input: 1 to 65 535
0: 1 000

External interpolation

If you connect encoders with TTL signals and an external interpolation unit through the TTL/1 V_{PP} adapter to the control:

▶ In MP340.x, enter the interpolation factor of the external interpolation unit.

MP340.x **Interpolation factor for external interpolation**
Input: 0 to 99
0 = 1: No external interpolation

Encoder signals

Position encoders with 1-V_{PP} or 11- μA_{PP} signals can be connected to the MC 422.

- With MP115.0, you set the 1-V_{PP} or 11-μA_{PP} signal.
- With MP115.2, you set the maximum input frequency.

Note

The incremental track data must be entered for the corresponding position encoder inputs for encoders with EnDat interfaces.

MP115.0 **Position encoder input 1 V_{PP} or 11 μA_{PP}**

Format: %xxxxxxxxxxx

Input: Bit 0 to bit 5: Position encoder inputs X1 to X6
Bit 6 to bit 9: Position encoder inputs X35 to X38
Bit 10: No function
0: 1 V_{PP}
1: 11 μA_{PP}

MP115.1 **Reserved**

Format: %xxxxxxxxxxx

Input: Enter %00000000000

MP115.2 **Input frequency of the linear encoder inputs**

Format: %xxxxxxxxxxx

Input: Bit 0 to bit 5: Position encoder inputs X1 to X6
Bit 6 to bit 9: Position encoder inputs X35 to X38
Bit 10: No function

For 1 V_{PP}:	0: 33 kHz	
	1: 350 kHz	
For 11 μA_{PP}:	0: 33 kHz	
	1: 150 kHz	

Direction of traverse

With MP210 and MP1040 you define the direction of traverse of the axes. The counting direction depends on the position in which the encoders are mounted. Configuration errors in these parameters provoke the error message **MOVEMENT MONITORING ERROR IN <AXIS>.** Through W1030 the NC informs the PLC of the direction in which the axes traverse.

If the speed encoder is also used for position measurement, MP210 must be set for the speed encoder. Configuration errors in these parameters provoke the error message **Standstill monitoring <in axis>.**

MP210 **Counting direction of position encoder output signals**
Format: %xxxxxxxxxxxxxx
Input: Bits 0 to 13 represent axes 1 to 14
0: Positive
1: Negative

MP1040 **Analog axes: Polarity of nominal value voltage**
Digital axes: Algebraic sign of the nominal speed value
Format: %xxxxxxxxxxxxxx
Input: Bits 0 to 13 represent axes 1 to 14
0: Positive
1: Negative

		Set	Reset
W1030	**Current direction of traverse** Bits 0 to 8 represent axes 1 to 9 0: Positive traverse direction 1: Negative traverse direction	NC	NC

Note

The counting direction of the speed encoder signals is defined in the motor table (DIR column). If the error message **C3B0 Motor <AXIS> does not rotate** appears, you must change this entry.

Encoder monitoring

HEIDENHAIN contouring controls monitor the signal transmission from the encoders. With machine parameters MP20.x and MP21.x, you activate the monitoring function for the position encoders. The following criteria are checked:

Criterion	Error message
Absolute position with distance-coded reference marks	**Encoder <AXIS> DEFECTIVE**
Amplitude of encoder signals	**Encoder AMPLITUDE TOO LOW <AXIS>**
Edge separation of encoder signals	**Encoder <AXIS>: FREQUENCY TOO HIGH**

MP20 **Monitoring functions for the axes**
Format: %xxxxxxxxxxxxxx
Input: Bits 0 to 13 represent axes 1 to 14
0: Monitoring not active
1: Monitoring active
MP20.0 Absolute position of distance-coded reference marks
MP20.1 Amplitude of encoder signals
MP20.2 Edge separation of encoder signals

MP21 **Monitoring functions for the spindle**
Format: %xx
Input: Bit 0 – Spindle 1
0: Monitoring not active
1: Monitoring active
Bit 1 – Spindle 2
0: Monitoring not active
1: Monitoring active
MP21.0 Nonfunctional
Input: 0
MP21.1 Amplitude of encoder signals
MP21.2 Edge separation of encoder signals

Note

Please note:

- For digital axes the speed encoders are always monitored.
- For more information on error messages from speed encoders, see "Error Messages" section.

Monitoring for encoders with EnDat interface:

In the event of a disturbance, the error message **`EnDat defective <error code> <axis>`** will appear.

The error code is shown in hexadecimal notation. Error codes may also appear combined, in which case they add themselves together.

There are two possible types of errors:

- The encoder reports an error.
- Access to the encoder via the EnDat interface is faulty.

Codes for errors reported by the encoder:

Error code	Meaning
0x00000001	Light source defective
0x00000002	Signal amplitude too small
0x00000004	Incorrect position value
0x00000008	Overvoltage
0x00000010	Undervoltage
0x00000020	Overcurrent
0x00000040	Replace battery
0x00000080	Reserved
0x00000100	Reserved
0x00000200	Reserved
0x00000400	Reserved
0x00000800	Reserved
0x00001000	Reserved
0x00002000	Reserved
0x00004000	Reserved
0x00008000	Reserved

Error codes if the access to the encoder via the EnDat interface is faulty:

Error code	Meaning
0x80010000	Delete the alarm bit
0x80020000	Read the alarm status
0x80040000	Read the number of pulses
0x80080000	Read the number of signal periods
0x80100000	Read the number of differentiable revolutions
0x80200000	Read the measuring steps
0x80400000	Read the series number
0x80800000	Read the type of encoder
0x81000000	Read the position value
0x82000000	Reserved
0x84000000	Reserved
0x88000000	Read the checksum
0x90000000	Alarm bit remains set
0xA0000000	Timeout while waiting for data - signal “high”
0xC0000000	Timeout while waiting for data - signal “low”
0x80000000	Error during access to EnDat interface

Speed encoder

The iTNC 530 uses the **Type of encoder** entry in the “motor.mot” motor table. If an encoder with Z1 track is entered in the motor table, the message **C310 Z1 track error** appears in the event of an error. If an encoder with EnDat interface is entered in the motor table, the control attempts to communicate with the encoder. If this fails, the error message **C3F0 EnDat not found <axis>** appears.

Warning

If you use the HEIDENHAIN standard motor table motor.mot and motors with EnDat encoders, you might have to change the entry for the motor in the SYS column (type of encoder) of the motor table or enter a new motor.

- SYS = 1: Incremental rotary encoder with Z1 track
- SYS = 2: Absolute speed encoder with EnDat interface

6.1.4 Assignment for Axes

With the following machine parameters you assign the position and speed encoder inputs, the speed command output and the machine parameter block of the current and speed controller to the individual logic axes:

- In MP110.x you enter the number of the position encoder input. An error message appears if an invalid number is entered.
- In MP112.x you enter the number of the speed encoder input.
- In MP120.x you enter the number of the speed command output (analog or digital).
- In MP130.x you enter index number y of machine parameter block MP2xxx.y of the current and speed controller. This way different machine parameter blocks MP2xxx.y can be used for the axis and spindle in C-axis operation.

Note

Depending on the maximum spindle speed, it might no longer be possible to use all PWM outputs. See "Maximum spindle speed" on page 6 – 14.

If MP120.x = 0, then the axis will only be displayed.

Digital axes: If MP110.x = 0, then the speed encoder (with or without EnDat interface) is also used for position control.

Note

For axes 7 to 10, only speed encoder inputs X80 to X83 and speed command outputs X57 to X60 can be used.

MP110.x **Assignment of position encoder inputs to the axes**
Input: 0: No position encoder input
1 to 6: Position encoder inputs X1 to X6
35 to 38: Position encoder inputs X35 to X38

MP112.x **Assignment of speed encoder inputs to the axes**
Input: 0: No speed encoder input
15 to 20: Speed encoder inputs X15 to X20
80 to 85: Speed encoder inputs X80 to X85

MP120.x **Nominal speed command outputs of the axes**
Input: 0: No servo-controlled axis
1 to 6: Analog speed command outputs 1 to 6 (X8)
7 to 12: Analog speed command outputs 7 to 12 (X9)
51 to 62: Digital nominal speed value output X51 to X62

MP130.x **Y index of the machine parameters MP2xxx.y for the axes**
Input: 0 to 12

6.1.5 Assignment for Spindles

With the following machine parameters you assign the position and speed encoder inputs, the speed command output and the machine parameter block of the current and speed controller to the spindle/spindles:

- In MP111.x you enter the number of the position encoder input. An error message appears if an invalid number is entered.
- In MP113.x you enter the number of the speed encoder input.
- In MP121.x you enter the number of the speed command output.
- In MP131.x and MP132.x you enter index number y of machine parameter block MP2xxx.y of the current and speed controller.

First spindle			**Second spindle**		
Position	**Rotational speed**	**Nominal value**	**Position**	**Rotational speed**	**Nominal value**
X1 to X6, X35 to X38	X15 to X20, X80 to X83	Digital: X51 to X56, X57 to X60	X1 to X6, X35 to X38	X15 to X20, X80 to X83	Digital: X51 to X56, X57 to X60
X1 to X6, X35 to X38	X15 to X20, X80 to X83	Digital: X51 to X56, X57 to X60	X1 to X6, X35 to X38	–	Analog: 1 to 12
X1 to X6, X35 to X38	–	Analog: 1 to 12	X1 to X6, X35 to X38	–	Analog: 1 to 12

Maximum spindle speed

The individual PWM outputs are assigned to different controller groups:

- Controller group 1: X51, X53, X54
- Controller group 2: X52, X55, X56
- Controller group 3: X57, X59, X60
- Controller group 4: X58

If all PWM outputs of a controller group are used, the maximum spindle speed is:

$$\frac{60000\ \text{rpm}}{\text{No. of pole pairs}}$$

If only the first PWM output of a controller group is used, the maximum spindle speed is:

$$\frac{80\,000\ \text{rpm}}{\text{No. of pole pairs}}$$

The unused PWM outputs must not be entered in MP120.x or. MP121.x. Otherwise, the DSP error message **`C440 PWM frequency <Axis>`** will appear.

The PWM frequency can be set separately for each of the controller groups, See "PWM Frequencies of the CC 422" on page 6 – 240.

MP111	**Position encoder input for the spindle/spindles**
Input:	0: No position encoder input 1 to 6: Position encoder inputs X1 to X6 35 to 38: Position encoder inputs X35 to X38
MP111.0	Position encoder input for the first spindle
MP111.1	Position encoder input for the second spindle
MP113	**Speed encoder for the spindle/spindles**
Input:	0: No speed encoder input 15 to 20: Speed encoder inputs X15 to X20 80 to 85: Speed encoder inputs X80 to X85
MP113.0	Speed encoder input for the first spindle
MP113.1	Speed encoder input for the second spindle
MP121	**Nominal speed command output of the spindle/spindles**
Input:	0: No servo-controlled spindle 1 to 6: Analog speed command outputs 1 to 6 (X8) 7 to 12: Analog speed command outputs 7 to 12 (X9) 51 to 62: Digital nominal speed value output X51 to X62
MP121.0	Nominal speed command output of the first spindle
MP121.1	Nominal speed command output of the second spindle
MP131	**Y index of the machine parameters MP2xxx.y for the spindle(s) in operating mode 0**
Input:	0 to 12
MP131.0	Y index of first spindle
MP131.1	Y index of second spindle
MP132	**Y index of the machine parameters MP2xxx.y for the spindle(s) in operating mode 1**
Input:	0 to 12
MP132.0	Y index of first spindle
MP132.1	Y index of second spindle

6.1.6 Reading Axis Information

Module 9038 Reading general axis information

With Module 9038 you can interrogate the general status information of the axes. You can ask for the status of a specific axis or of all axes at once. Bits 0 to 8 represent axes 1 to 9. Bit 15 corresponds to the spindle. If status information is read for only one axis, only bit 0 is changed. The following table shows the meanings of the return codes:

Status information	Meaning
0	0: Axis (spindle) not active (MP10 or MP3010 or no encoder) 1: Axis (spindle) active
1	Depending on the current traverse range: 0: NC axis or not active 1: PLC axis
2	0: No servo-controlled axis (spindle), only display or not active 1: Servo-controlled axis (spindle)
3	Maximum temperature of the motor [°C]
4	0: No Hirth axis 1: Hirth axis (MP420)
5	Hirth grid [1/10 µm] (MP430)
6	Modulo value (MP810)
7	0: Linear axis or not active 1: Rotary axis in at least one of the traverse ranges
8	0: Analog axis (spindle) or not active 1: Digital axis (spindle)

Call:

```
PS    B/W/D/K   <Axis>
                Axis-specific: 0 to 8 represent axes 1 to 9,
                15 represents the spindle
                Bit-encoded output for all axes: –1
PS    B/W/D/K   <Status information>
                See table above
CM    9038
PL    B/W/D     <Information>
```

Error detection:

Marker	Value	Meaning
M4203	0	Information was read
	1	Error code in W1022
W1022	1	Status information not available on this iTNC
	2	Axis does not exist

Current tool axis

You can define the current tool axis in two ways in the NC block:

- In the HEIDENHAIN conversational dialog with TOOL CALL
- In ISO programming with G17 to G20

In the PLC you can interrogate the current tool axis via marker:

		Set	Reset
M4526	**Axis 1 is tool axis**	NC	NC
M4527	**Axis 2 is tool axis**	NC	NC
M4528	**Axis 3 is tool axis**	NC	NC
M4529	**Axis 4 is tool axis**	NC	NC
M4530	**Axis 5 is tool axis**	NC	NC
M4531	**Axis 6 is tool axis**	NC	NC
M4532	**Axis 7 is tool axis**	NC	NC
M4533	**Axis 8 is tool axis**	NC	NC
M4534	**Axis 9 is tool axis**	NC	NC

6.1.7 Traverse Ranges

You can divide the working range of the machine into three traverse ranges, e.g. one for each workpiece. Each traverse range is limited by a software limit switch.

For the software limit switch of a traverse range:

- The datum is the machine datum (MP960.x).
- Software limit switches for tilting axes must be activated with MP812 when MP810.x ≠ 0
- The traverse range can be limited further through the MOD function.
- If a software limit switch is activated, the error message **LIMIT SWITCH <AXIS>** appears.
- Software limit switches can be overwritten with **FN17:SYSWRITE,** e.g. for automatic tool change. This function is effective only until the next GOTO command (GOTO key or FN9 to FN12) or the end of the program.

Determining range of traverse

- You can determine the current range of traverse with Module 9035

Module 9035 Reading status information

Call:

PS	B/W/D/K	<27>
CM	9035	
PL	B/W/D	<Range of traverse> 0 to 2: Traverse ranges 1 to 3

Error detection:

Marker	Value	Meaning
M4203	0	No error
	1	Error code in W1022
W1022	1	Status information invalid
	20	Call was not in a submit or spawn job

Selecting the traverse range

You can switch the range of traverse in two ways:

- Select the traverse range with Module 9151 or 9152. With Module 9152 you can change the axis display at the same time.

Or

- Select the traverse range with M4574 and M4575 according to the table below.
- In all operating modes you must activate the traverse range with strobe marker M4135.

You may only use the traverse range switching function via M4574 and M4575 during an M/S/T/Q strobe in all operating modes (except for **Manual Operation** and **El. Handwheel**).

M4574	M4575	Traverse range/Datum
0	0	Range 1
1	0	Range 2
0	1	Range 3

		Set	Reset
M4574	**Select the traverse range (with M4575)**	PLC	PLC
M4575	**Select the traverse range (with M4574)**	PLC	PLC
M4135	**Strobe marker for selecting the traverse range**	PLC	NC

Module 9151 Select traverse range and axis designation

With Module 9151 you can select the traverse range and the axis designation in one step. The axis designations in MP100.x are overwritten and cannot be activated until the module has received the axis designation –1, a traverse range has been activated with M4135, MP100.x is edited, or the control has been reset.
When the module is called it sets M4135. After switchover the NC resets M4135.

Call:

PS	B/W/D/K/S<String with axis designation>	
		Format: XYZABCUVWxyzabcuvw
		Characters 1 to 9 represent axes 1 to 9
		With –1 the axis designations from M100.x are valid
PS	B/W/D/K	<Traverse range>
		0 to 2: Range of traverse
		–1: Do not change range of traverse
CM	9151	

Error detection:

Marker	Value	Meaning
M4203	0	Traverse range/axis designation switched over
	1	Error code in W1022
W1022	2	Invalid value for traverse range
	3	For the axis assignment, neither a string nor –1 was transferred
	21	The module was called during a running part program or without an M/S/T/Q strobe

Module 9152 Selecting traverse range, axis display and axis designation

With Module 9152 you can select the traverse range, the axis designation, and the axis display. The axis designations in MP100.x and the axis display in MP7291 are overwritten and cannot be activated until the module has received –1 for the axis designation and axis display, a traverse range has been activated with M4135, MP100.x or MP7291 have been edited, or the control has been reset.

When the module is called it sets M4135. After switchover the NC resets M4135.

Call:

PS	B/W/D/K/S<String with IV and V key configuration>	
		Format: AB
		The first character represents the IV key, the second character represents the V key
		With –1 the key configuration from MP410 is valid
PS	B/W/D/K/S<String with axis display>	
		Format: SWVUCBAZYXwvucbazyx
		Characters 1 to 9 (from the right) represent lines 1 to 9
		Character 10 = S always in line 10
		With –1 the axis display from MP7291 is valid
PS	B/W/D/K/S<String with axis designation>	
		Format: XYZABCUVWxyzabcuvw
		Characters 1 to 9 represent axes 1 to 9
		With –1 the axis designations from M100.x are valid
PS	B/W/D/K	<Traverse range>
		0 to 2: Range of traverse
		–1: Do not change range of traverse
CM	9152	

Error detection:

Marker	Value	Meaning
M4203	0	Traverse range, axis designation and axis display are switched
	1	Error code in W1022
W1022	2	Invalid value for traverse range, or string for axis configuration, axis display or key configuration is too long
	3	For the axis assignment, axis display or key configuration, neither a string nor –1 was transferred
	21	The module was called during a running part program or without an M/S/T/Q strobe

Setting the software limit switches

With the following machine parameters, you can set the software limit switches for the various ranges of traverse. The position values are with respect to the machine datum. Ranges of traverse 2 and 3 do not become effective until they are activated by M4574, M4575 and M4135 or with Module 9151 or 9152.

Note

The values for MP910.x, MP911.x, MP912.x, MP920.x, MP921.x and MP922.x can be transferred with the actual-position-capture key.

MP910.x **Positive software limit switches, traverse range 1 (default setting after power on)**
Input: –99 999.9999 to +99 999.9999 [mm] or [°]

MP911.x **Positive software limit switches, traverse range 2**
Input: –99 999.9999 to +99 999.9999 [mm] or [°]

MP912.x **Positive software limit switches, traverse range 3**
Input: –99 999.9999 to +99 999.9999 [mm] or [°]

MP920.x **Negative software limit switches, traverse range 1 (default setting after power on)**
Input: –99 999.9999 to +99 999.9999 [mm] or [°]

MP921.x **Negative software limit switches, traverse range 2**
Input: –99 999.9999 to +99 999.9999 [mm] or [°]

MP922.x **Negative software limit switches, traverse range 3**
Input: –99 999.9999 to +99 999.9999 [mm] or [°]

MP7490 **Functions for traverse ranges**
Format: %xxxx
Input: Bit 0 = 0: Display one traverse range via MOD
Bit 0 = 1: Display three traverse ranges via MOD
Bit 1 = 0: Each traverse range has its own datum
(and 3 memories for the positions of the swivel head)
Bit 1 = 1: One datum for all traverse ranges

The NC reports the activation of limit switches to the PLC in words W1034 and W1036:

		Set	Reset
W1034	**Positive software limit switch was traversed** Bits 0 to 8 represent axes 1 to 9	NC	NC
W1036	**Negative software limit switch was traversed** Bits 0 to 8 represent axes 1 to 9	NC	NC

6.1.8 Lubrication Pulse

You can define the traverse distance for each axis after which the PLC commands lubrication:

- In MP4050.x you define the traverse distance at which the lubrication pulse is to be output. The NC reports in W1056 when the entered distance in an axis has been exceeded.
- With W1058 you reset the distance counter to 0 after lubrication.

MP4050.0-8 Traverse distance for lubrication of axes 1 to 9
Input: 0 to 99 999.999 [m] or [1000°]

		Set	Reset
W1056	**Lubrication pulse: Value in MP4060 exceeded** Bits 0 to 8 represent axes 1 to 9	NC	NC
W1058	**Resetting the accumulated distance** Bits 0 to 8 represent axes 1 to 9	PLC	PLC

6.2 PLC Axes

You can assign the controlled axes individually to the PLC.

Remember that:

- PLC axes can be operated with following error (also called lag) or with velocity feedforward control. The axis-specific jerk (MP1097.x and MP1098.x) is accounted for.
- You can start more than one axis simultaneously. However, the axes are not interpolated with each other.
- PLC axes are positioned by the shortest path if you enter a modulo value in MP810.x.
- Up to 20 commands (such as positioning, override settings, etc.) for PLC axes can be executed per run-through of the PLC program.

With MP100.x you define for every traverse range which axes the PLC controls and which the NC controls. Uppercase letters represent NC axes, and lowercase letters represent PLC axes. To indicate axes that are not present, mark them with a hyphen "-".

MP100	**Designation of axes**
Format:	XYZABCUVWxyzabcuvw-
Input:	Bits 0 to 8 represent axes 1 to 9
MP100.0	Traverse range 1
MP100.1	Traverse range 2
MP100.2	Traverse range 3

Module 9120 Starting a PLC axis

This module starts the positioning of a PLC axis regardless of other processes in the control.

Conditions:

- Status changes through a PLC positioning command are not detected until the next PLC scan.
- The axis must be activated in MP10 and identified in MP100 as a PLC axis.
- Traverse over the software limit switches is not checked.
- The axis must be stationary before positioning. Interrupt a running positioning movement with Module 9121.
- Feed-rate override is disabled. To change the feed rate, use Module 9124.
- If no reference mark has been traversed, the positioning process builds on the counter value as it was upon switch-on.

Call:

PS	B/W/D/K	<Axis> 0 to 8 represent axes 1 to 9
PS	B/W/D/K	<Target position> Input unit: [0.0001 mm]
PS	B/W/D/K	<Feed rate> Input unit: [mm/min]
PS	B/W/D/K	<Mode> Bit 0: Type of target position input 0: Absolute, i.e. relative to the machine datum 1: Incremental
CM	9120	
PL	B/W/D	<Error code> 0: No error. Positioning was started. 1: Axis does not exist 2: Not a PLC axis 3: Axis is already being positioned 4: Absolute position is outside of modulo range 5: Programmed axis not in closed loop 6: Feed rate not permitted

Module 9121 Stopping a PLC axis

Stops a running PLC positioning process in an axis.

Condition:

- Status changes through a PLC positioning command are not detected until the next PLC scan.

Call:

PS	B/W/D/K	<Axis> 0 to 8 represent axes 1 to 9
CM	9121	
PL	B/W/D	<Error code> 0: Positioning is canceled 1: Axis does not exist 2: Not a PLC axis 3: Axis was already stationary

Module 9122 Status of PLC axis

Request for PLC positioning status.

Condition:

- Status changes through the PLC positioning command are not detected until the next PLC scan.

Call:

PS	B/W/D/K	<Axis> 0 to 8 represent axes 1 to 9
CM	9122	
PL	B/W/D	<Status> Bit 0 – A PLC axis? 0: NC axis or not active 1: PLC axis Bit 1 – Reference mark 0: Reference mark not yet traversed 1: Reference mark traversed Bit 2 – Positioning 0: Inactive 1: Active Bit 3 – Direction of motion 0: Positive 1: Negative Bit 4 – Positioning error 0: No positioning errors occurred 1: Positioning error Bit 5 – Close-loop or open-loop axis 0: Close-loop axis was programmed 1: Axis programmed which was switched to open-loop in Module 9155 Bit 6 – Target position reached? 0: Target position not yet reached 1: Target position reached

Module 9123 Traversing the reference marks of PLC axes

Traverse the reference marks as for NC axes. This module is not suitable for encoders with distance-coded reference marks (use Module 9220).

- You can use the same procedure to traverse a reference mark for PLC axes as for NC axes. Use Module 9123 only if no conventional procedure is possible.
- Module 9123 moves the axis in the given direction until the reference mark has been traversed. The axis stops next to the reference mark, offset by the braking path.

Call:

PS	B/W/D/K	<Axis> 0 to 8 represent axes 1 to 9
PS	B/W/D/K	<Feed rate> Input unit: [mm/min]
PS	B/W/D/K	<Mode> Bit 0: Direction of traverse 0: Positive 1: Negative
CM	9123	
PL	B/W/D	<Error code> 0: No error. Positioning was started. 1: Axis does not exist 2: Not a PLC axis 3: Axis is already being positioned 5: Programmed axis not in closed loop 6: Feed rate not permitted

Module 9124 Feed rate override for PLC axis

Enters the feed rate override for one PLC axis.

Conditions:

- After interruption of a PLC program, the override value is set to 100%.
- When a positioning is started, the last defined override value is in effect.
- The override value can also be changed during a positioning movement.

Call:

PS	B/W/D/K	<Axis> 0 to 8 represent axes 1 to 9
PS	B/W/D/K	<Override> Input unit: 0 to 10 000, corresponds to 0 to 100% in 0.01% steps.
CM	9124	
PL	B/W/D	<Error code> 0: No error, override value was set 1: Axis does not exist 2: Not a PLC axis 3: Override value incorrect

Module 9125 Stop PLC axis at next Hirth grid position

Stop an already started PLC-positioning of an axis at the next Hirth grid position.

Call:

PS	B/W/D/K	<Axis>
		0 to 8 represent axes 1 to 9
CM	9125	
PL	B/W/D	<Error code>
		0: Positioning is canceled
		1: Axis does not exist
		2: Not a PLC axis
		3: Axis was already stationary
		4: Axis is not a Hirth axis (MP420.x)

6.3 PLC Positioning

You can position the axes directly through the PLC. See page 6 – 193 for PLC positioning of the main spindle.

Prerequisites

The following constraints apply to a PLC positioning command:

- It is possible in the Manual and Handwheel modes only while there is no positioning movement.
- Possible in the other modes of operation only with an M/S/T/Q strobe or if no part program is started.
- If the NC is positioning an axis, you can position additional axes only if they have already been defined as PLC axes. See "PLC Axes" on page 6 – 25.

Programming

You start a PLC positioning movement with Module 9221, and you can interrogate the status with Module 9222. After Module 9221 has been called, markers M4120 to M4128 are set (depending on MP4020 bit 2). If you reset these markers, positioning is canceled. This is necessary if you would like to change a parameter, such as the feed rate, during positioning.

The following conditions apply to a PLC positioning command:

- If more than one axis is moved simultaneously, the axes will be interpolated.
- If you start another axis during a PLC positioning movement,
  - the first positioning command will be canceled and
  - the resulting positioning movement will be executed in all axes.
- Tool compensation is not included. Before a PLC positioning command you must end any tool compensation.
- A PLC positioning movement is not displayed in the test graphics.

The NC cancels a PLC positioning movement under the following conditions:

- If in the Manual or Handwheel modes there is an NC STOP
- If in the automatic operating modes there is an NC STOP and "internal stop"
- An EMERGENCY STOP
- An error message that results in a STOP
- A reset of the Markers M4120 to M4128 (depending on MP4020 bit 2)

Module 9221 Starting a PLC positioning movement

Starts a PLC positioning movement in one axis.

Call:

PS	B/W/D/K	<Axis> 0 to 8 represent axes 1 to 9
PS	B/W/D/K	<Target position> Input unit: 0.0001 mm
PS	B/W/D/K	<Feed rate> Input unit: mm/min
PS	B/W/D/K	<Mode> Bit 0 – Definition of the target position 0: Absolute, i.e. relative to the machine datum 1: Incremental Bit 1 – Software limit switch 0: Inactive 1: Active
CM	9221	
PL	B/W/D	<Error code> 0: Positioning is being started 1: Axis is not in a closed loop or is an auxiliary axis 2: Inadmissible values for the feed rate 3: Axis has not traversed the reference mark 4: No M/S/T/Q strobe during started part program 5: Programmed axis not in closed loop

Module 9222 Status request of PLC positioning movement

With this module you can interrogate the status of a PLC positioning movement.

Call:

PS	B/W/DK	<Axis> 0 to 8 represent axes 1 to 9
CM	9222	
PL	B/W/D	<Status> 0: No PLC positioning was started 1: Target position reached 2: PLC positioning was started 3: Due to cancellation, target position not reached 4: Target position is outside of traverse range 5: Positioning not possible (e.g. due to “free rotation”)

PLC positioning through markers and words

To ensure compatibility, a PLC positioning command is permissible for axes 1 to 9 with M4120 to M4128, D528 to D544 and W560 to W568.

Warning

Software limit switches are ignored!

Programming:

- Enter the target position in the double words D528 to D544 in the unit [0.0001 mm].
- Enter the feed rate in words W560 to W568 [mm/min].
- To start the PLC positioning movement: Set markers M4120 to M4124 for the desired axis.

		Set	Reset
D528-544	**Target position for PLC positioning**	PLC	PLC
W560-568	**Feed rate for PLC positioning**	PLC	PLC
M4120	**PLC positioning axis 1 active**	NC/PLC	NC/PLC
M4121	**PLC positioning axis 2 active**	NC/PLC	NC/PLC
M4122	**PLC positioning axis 3 active**	NC/PLC	NC/PLC
M4123	**PLC positioning axis 4 active**	NC/PLC	NC/PLC
M4124	**PLC positioning axis 5 active**	NC/PLC	NC/PLC
M4125	**PLC positioning axis 6 active**	NC/PLC	NC/PLC
M4126	**PLC positioning axis 7 active**	NC/PLC	NC/PLC
M4127	**PLC positioning axis 8 active**	NC/PLC	NC/PLC
M4128	**PLC positioning axis 9 active**	NC/PLC	NC/PLC

6.4 Axis Error Compensation

The iTNC can compensate the following mechanical axis errors:

- Backlash
- Linear axis errors
- Nonlinear axis errors
- Thermal expansion
- Reversal spikes during circular movements
- Stiction

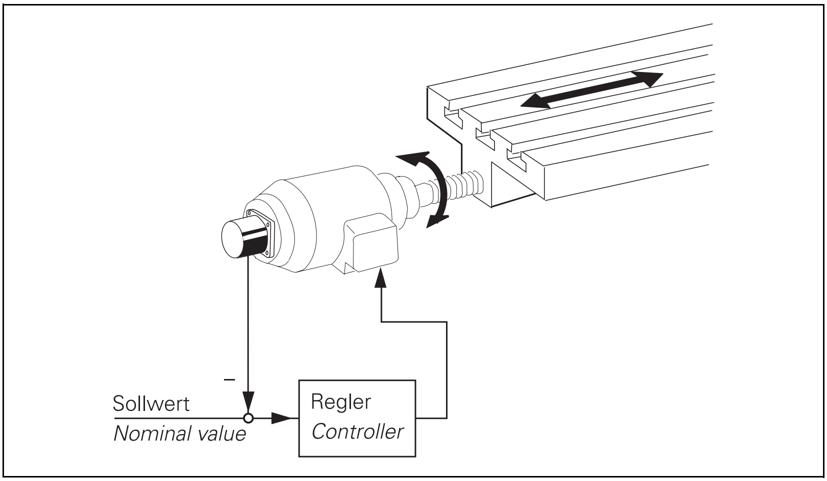
Per axis you can activate either the linear or the nonlinear axis error compensation. All other types of compensation are nonexclusive.

6.4.1 Backlash Compensation

Cause outside of the control loop

During a reversal in axis direction, there is often a little play between the rotary encoder and table. This play is referred to as backlash.

Positive backlash: The rotary encoder reading is ahead of the table. The table traverse is too short.
Negative backlash: The rotary encoder reading is behind the table. The table traverse is too long.



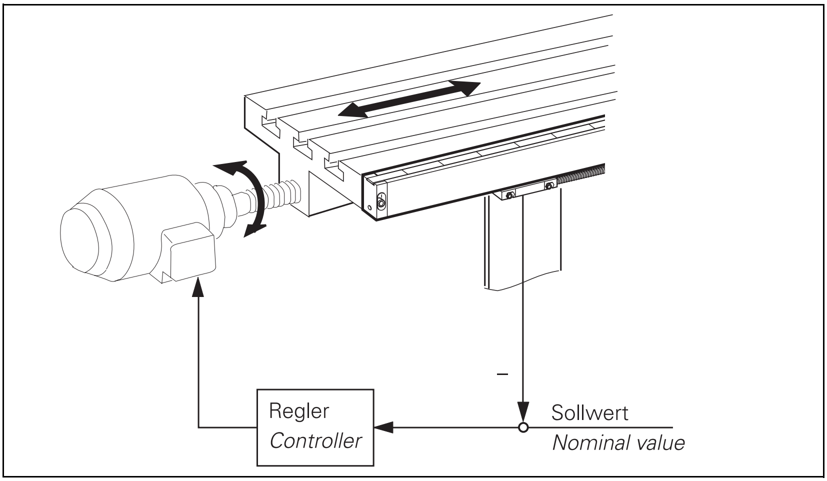
Compensation:

▶ In MP710, enter the value that the iTNC should add to or subtract from the encoder signal after a reversal in direction.

MP710.x **Backlash compensation**
Input: -1.0000 to +1.0000 [mm] or [°]

Cause within the control loop

If axis movement is measured with a linear encoder, the iTNC can compensate the play between the motor and the table. At the same time, the reversal spikes during circular movements are compensated: machine parameters MP711 to MP716 for "Compensation of reversal spikes" are **not** necessary.



Compensation:

- In MP750.x, enter the reversal error in mm.
- In MP752.x, enter the time in which the distance to be compensated should be traversed.

MP750.x **Backlash in axes 1 to 9**
Input: -1.0000 to +1.0000 [mm] or [°]

MP752.x **Compensation time for reversal error**
Input: 0 to 1000 [ms]

Example:

MP750.x: 0.03 mm
MP752.x: 15 ms

For every change in direction, a nominal speed command signal is output for 15 ms, which corresponds to a feed rate of 120 mm/min:

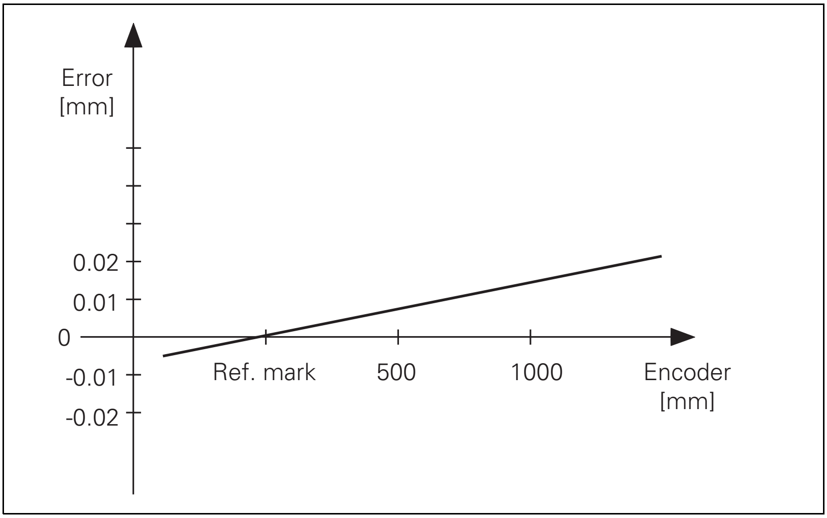
$$\frac{0.03\ \text{mm}}{15\ \text{ms}} = 120\ \text{mm/min}$$

6.4.2 Linear Axis Error Compensation

> **Note**
>
> Linear axis error compensation is not available for rotary axes!

For every linear axis you can compensate a linear axis error.

Positive linear axis error: The table moves too far.
Negative linear axis error: The table moves short.



Compensation:

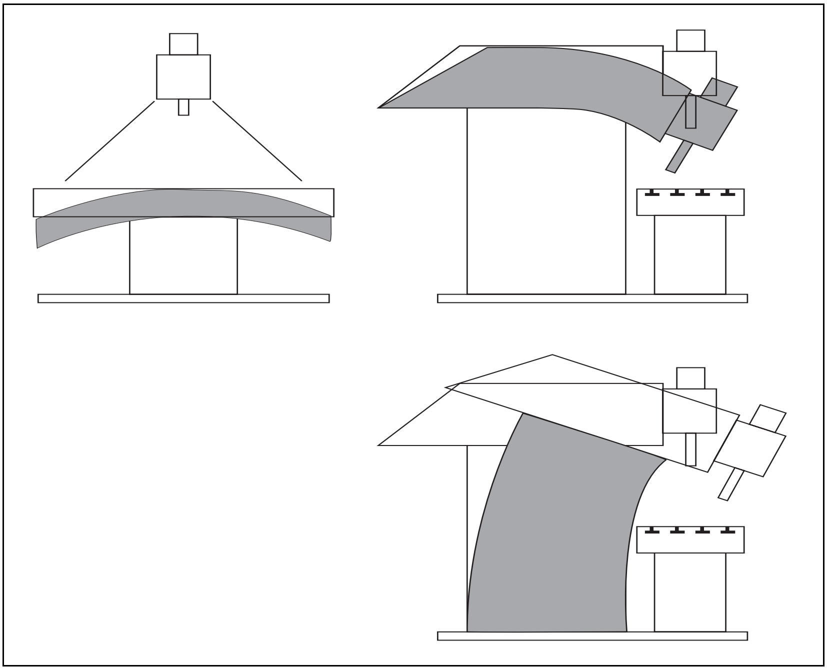
- In MP720, enter the axis error in [mm/m].
- With MP730, activate the linear axis error compensation.

MP720.x **Linear axis error compensation**
Input: –1.000 to +1.000 [mm/m]

MP730 **Selection of linear/nonlinear axis error compensation**
Format: %xxxxxxxxxxxxxx
Input: Bits 0 to 13 represent axes 1 to 14
0: Linear axis error compensation
1: Nonlinear axis error compensation

6.4.3 Nonlinear axis error compensation

Errors in machine geometry (e.g. an error in one axis caused by the sagging of another axis) or external influences (e.g. temperature) can cause nonlinear axis errors. These graphics show typical nonlinear axis errors:

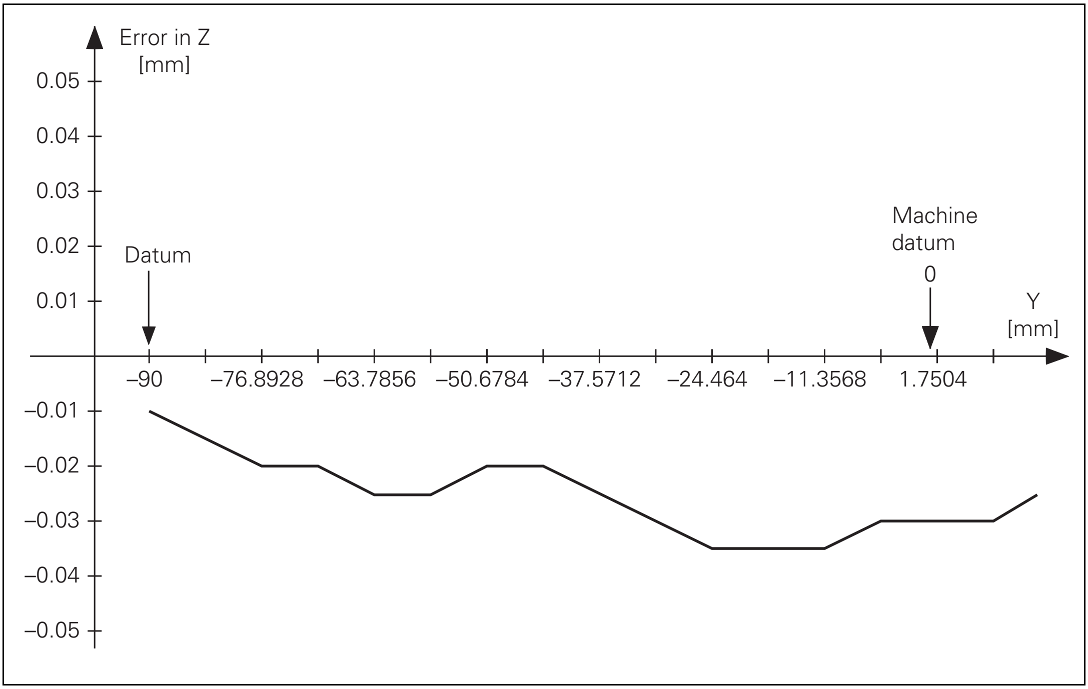


The best way to measure nonlinear axis error is with a comparator measuring system such as the HEIDENHAIN VM 101.

Note

The iTNC can compensate screw-pitch error and axis sag simultaneously.

The following graphic shows the trace of an axis sag error as a function of Y (Z = f(Y)):



Inputting the error trace

To enter the error trace in the iTNC:

- Ascertain the error trace with a comparator measuring system.
- To create a compensation-value table: Press the MOD key and enter the code number 807667; for each axis that is to be compensated for, use the program manager to create a compensation-value table with the name *.COM.
- Using soft keys (e.g. 1 OFF/ON), activate columns in the compensation value table only for the axes whose positions affect the error of the compensated axis.
- Begin your entry with the soft key HEAD LINE: Enter the datum for the compensation values as a distance from the machine datum (MP960.x).
- Enter a value for the spacing of the compensation points as a power to the base of 2. The maximum input value is 23.
  Example: The input value 16 represents 2^{16} = 65536 = 6.5536 mm
- Exit the header by pressing END.
- With the soft key APPEND N LINES, enter the number of compensation points:
  - Maximum of 256 compensation points per column
  - Maximum of 10 columns in all active compensation value tables
  - Total maximum of 1280 compensation points
- To enter compensation values: Enter only the break points of the error trace. The iTNC interpolates linearly between the break points.

Example

The following dependencies apply for axes 2 = Y and 3 = Z:

- Ballscrew pitch error in Z and Y: Z = F(Z) and Y = F(Y)
- Axis sag in Z depending on Y
- Traverse range: Z = 800 mm, Y = 500 mm
- Datum point of compensation values: Z = –200 mm, Y = –90 mm
- Desired spacing of compensation points: 7 mm

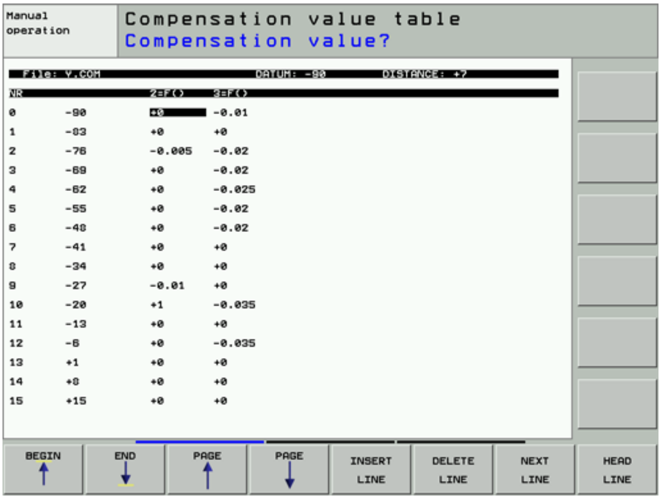
Calculations:

Input values for the spacing of the compensation points:
possible powers of 2^{16} = 6.5536 mm

Number of compensation points:

$$\frac{500\text{ mm}}{6.5536\text{ mm}} = 77 \text{ compensation points in Y}$$

$$\frac{800\text{ mm}}{6.5536\text{ mm}} = 123 \text{ compensation points in Z}$$

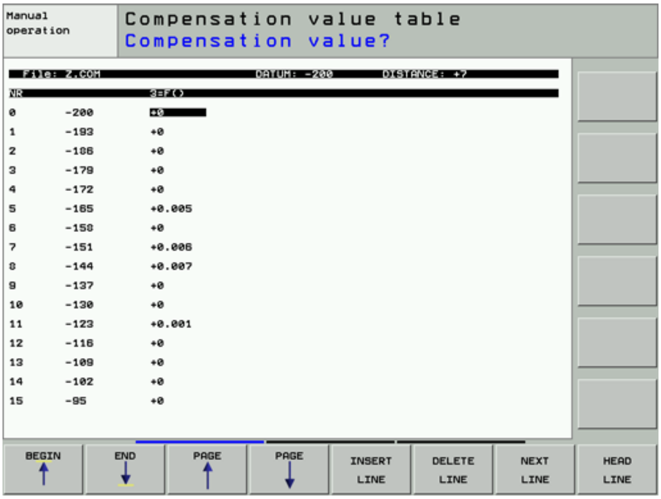

Manual operation
Compensation value table
Compensation value?

File: Y.COM DATUM: -90 DISTANCE: +7

NR		2=F()	3=F()
0	-90	+0	-0.01
1	-83	+0	+0
2	-76	-0.005	-0.02
3	-69	+0	-0.02
4	-62	+0	-0.025
5	-55	+0	-0.02
6	-48	+0	-0.02
7	-41	+0	+0
8	-34	+0	+0
9	-27	-0.01	+0
10	-20	+1	-0.035
11	-13	+0	+0
12	-6	+0	-0.035
13	+1	+0	+0
14	+8	+0	+0
15	+15	+0	+0

BEGIN | END | PAGE | PAGE | INSERT LINE | DELETE LINE | NEXT LINE | HEAD LINE

Y axis:
Ballscrew-pitch error in column 2 = F(), sag error in column 3 = F()


Manual operation
Compensation value table
Compensation value?

File: Z.COM DATUM: -200 DISTANCE: +7

NR		3=F()
0	-200	+0
1	-193	+0
2	-186	+0
3	-179	+0
4	-172	+0
5	-165	+0.005
6	-158	+0
7	-151	+0.006
8	-144	+0.007
9	-137	+0
10	-130	+0
11	-123	+0.001
12	-116	+0
13	-109	+0
14	-102	+0
15	-95	+0

BEGIN | END | PAGE | PAGE | INSERT LINE | DELETE LINE | NEXT LINE | HEAD LINE

Z axis:
Ballscrew-pitch error in column 3 = F()

Activate error compensation

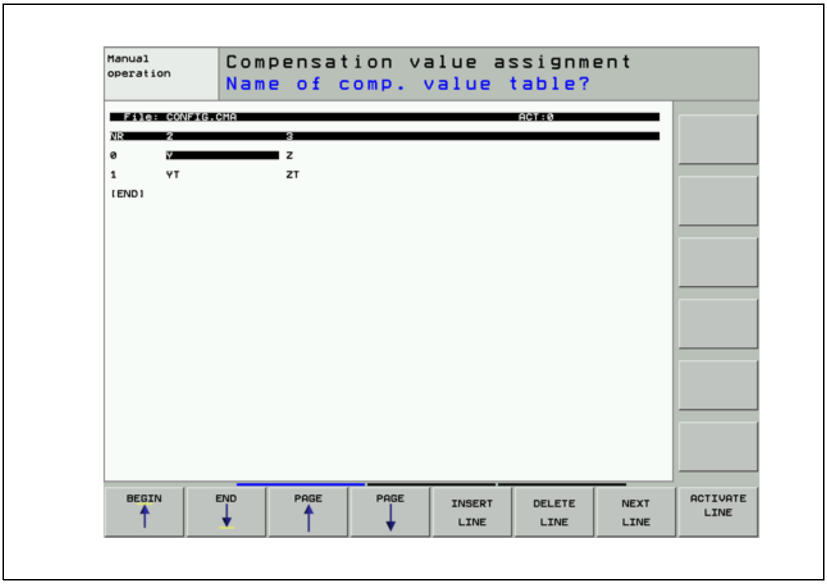
The appropriate machine parameter must be set for nonlinear axis error compensation, and the compensation value table must be registered in a configuration file:

- With MP730, activate for each axis the nonlinear axis error compensation.
- To create a configuration file: Press the MOD key and enter the code number 807667; with the program manager, create a configuration file with the extension CMA .
- Use soft keys (e.g. 1 OFF/ON) to activate columns for the axes for which you have created compensation value tables.
- Enter the compensation value table: You can assign more than one compensation value table to each axis; however, only one table at a time can be active. Enter the file names of the compensation value tables in the respective lines. You can select the active line either with the soft key SET ACTIV LINE or with Module 9095. With Module 9035 you can interrogate the active line.
- Enter the complete name of the configuration file with the extension CMA in the system file OEM.SYS with the command TABCMA=.

Example

Entry in the configuration file for axes 2 = Y and 3 = Z:

Compensation-value table valid for 20° = AXIS-Y.COM and AXIS -Z.COM
Compensation-value table valid for 35° = AXIS -YT.COM and AXIS -ZT.COM



MP730 **Selection of linear/nonlinear axis error compensation**

Format: %xxxxxxxxxxxxxx

Input: Bits 0 to 13 represent axes 1 to 14
0: Linear axis error compensation
1: Nonlinear axis error compensation

Module 9095 Select active line in configuration file

Call:

PS B/W/D/K <Active line>
CM 9095
PL B/W/D <Error code>
0: No error
1: Entered line does not exist
2: Compensation value table does not exist
3: Compensation value table > 256 entries
4: Maximum total number of compensation points exceeded
5: Too many compensation value tables
6: CMA file does not exist
7: Call was not from a submit job
8: Call during running program without strobe
10: CMA file is protected

Module 9035 Reading status information

Call:

PS B/W/D/K <19>
CM 9035
PL B/W/D <Active line number>
0: Line number
–1: No CMA file active

Error detection:

Marker	Value	Meaning
M4203	0	No error
	1	Error code in W1022
W1022	1	Status information invalid
	20	Call was not in a submit or spawn job

A rotary axis is a special case

For a rotary axis, only the compensation values for the entries of 0° to +60° are effective, relative to the machine datum. Therefore, the datum for the nonlinear compensation must lie within the 0° to +360° range. To compensate a full circle, set the compensation value datum to the machine datum.

Example: Rotary axis from –180° to +180°

Rotary axis:	0	...	+180	...	–179	...	–1	...	0
Corresponding angle for compensation values:	0	...	+180	...	+181	...	+359	...	0

6.4.4 Compensation of Thermal Expansion

To compensate thermal expansion, exact measurements of machine thermal behavior as a function of temperature (e.g., the center of axis expansion, the amount of the expansion) are necessary.

The temperatures measured by the Pt100 thermistors are saved in the PLC words W486 to W490. Since the thermal expansion of the axes is largely proportional to the temperature: you can directly determine the amount of expansion by multiplying the temperature value by a certain factor.

Compensation:

- Transfer the distance to be compensated to module 9231. At the same time, "lag tracking" becomes active. This means that the actual position is offset by a certain value per PLC cycle until the complete value is compensated.
- In MP4070, enter the value for the offset per PLC cycle.

For gantry axes, the compensation value must be transferred separately for each axis.

Heat compensation when using tilting axes is defined through machine parameters or the kinematics table. See "Temperature Compensation with Tilting Axes" on page 6 – 73

The actual value display does not change during compensation. As an alternative, for axes 1 to 5 you can enter the value to be corrected in W576 to W584.

MP4070 **Compensation amount per PLC cycle for lagged-tracking axis error compensation**
Input: 0.0001 to 0.5000 [mm]

		Set	Reset
W486 - 490	**Temperature input at X48 [0.5 °C]** Inputs 1 to 3	NC	NC
W576 - 584	**Lag-tracking axis-error compensation** For axes 1 to 5 Input: –32 768 to +32 767 [1/10 µm]	PLC	PLC

Module 9231 Compensation of thermal expansion

With Module 9231, thermal expansion can be compensated by transferring the axis number and a compensation value.

Call:

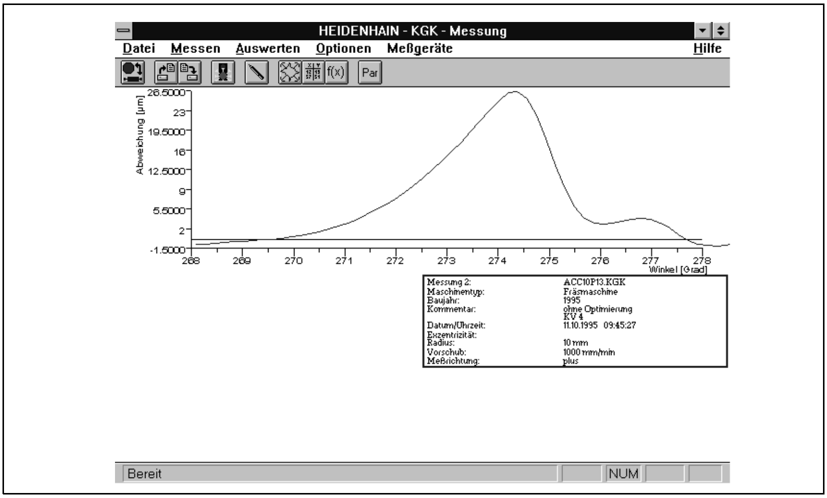
PS	B/W/D/K	<Axis> Axes 0 to 8
PS	B/W/D/K	<Compensation value> Range: –30000 to +30000 [1/10 µm]
CM	9231	

Error detection:

Marker	Value	Meaning
M4203	0	No error
	1	Error code in W1022
W1022	1	Invalid axis number
	2	Invalid compensation value
	24	The module was called in a spawn job or submit job

6.4.5 Compensation of Reversal Spikes during Circular Traverse

The static friction in the axis bearings during circular movement can lead to reversal spikes at the quadrant transitions. With the HEIDENHAIN KGM grid encoder and the ACCOM evaluation software you can measure the size and duration of the spikes.



Calculation

Duration of the reversal spike:

$$t_{SpD}[s] = \frac{\text{Peak width } [°] \cdot 2(\pi \cdot \text{radius [mm]} \cdot 60)}{360\ [°] \cdot \text{Feed rate [mm/min]}}$$

The spike width is [°] displayed in the diagram. The feed rate [mm/min] is the programmed tool path feed rate.

Compensation per control loop cycle time:

$$\text{Comp. [mm =]} \frac{\text{Reversal peaks [µm]} \cdot \text{control loop cycle time} \cdot [s] \cdot 10^{-3}}{0.5 \cdot t_{SpD}[s]}$$

The compensation value is entered in MP712.x.

Compensation

Digital axes:

You must compensate friction in the range of the speed controller (MP2610 to MP2620). Do not compensate with MP711 to MP716. See "Compensation of Sliding Friction (Only for Digital Axes)" on page 6 – 48.

Analog axes:

If you have compensated the **backlash** with MP750, there should be no more reversal spikes. If there are, compensate them with MP711 to MP716.

Compensation:

- In MP711.x, enter the height of the spike.
- In MP712.x, enter the amount of the reversal spike that is to be compensated per control loop cycle (see "Calculation" above).

MP711.x **Height of peaks during circular movement (only analog)**
Input: -1.0000 to +1.0000 [mm] (digital: 0)

MP712.x **Compensation value per control loop cycle time**
Input: 0.000 000 to 99.999 999 [mm] (digital: 0)

If the compensation has no effect, it may be because the machine's dynamic performance is too weak. You can selectively increase the contour accuracy with a higher k_V factor. With the M function M105 you can switch to a second set of k_V factors: In this way a second set of machine parameters becomes active for reversal spike compensation (MP715.x and MP716.x). M106 resets M105.

- Enable the M functions M105/M106 with MP7440, bit 3.
- In MP715.x, enter the height of the spike.
- In MP716.x, enter the amount of the reversal spike that is to be compensated per control loop cycle (see "Calculation" above)

MP7440 **Output of M functions**
Format: %xxxxx
Input: Bit 3 – switching the k_V factors with M105/M106
0: Function is not in effect
1: Function is effective

MP715.x **Height of peaks during circular movement (only analog) with M105**
Input: -1.0000 to +1.0000 [mm] (digital: 0)

MP716.x **Compensation value per control loop cycle time with M105**
Input: 0.000 000 to 99.999 999 [mm] (digital: 0)

6.4.6 Compensation of Static Friction

On guideways with high static friction (stick-slip friction), a following error can occur at low feed rates during operation with velocity feedforward control. This error can be compensated by the iTNC. You can measure following error by using, for example, the integrated oscilloscope of the iTNC.

Compensation of static friction works only under velocity feedforward control. If it is also to work in manual operating modes, you must activate velocity feedforward control in each axis with MP1391.x for manual operation.

Calculations

For compensation of static friction, an additive nominal velocity is output whose value F_{zus} is calculated from the factor for static friction compensation:

$$F_{zus} = \frac{\Delta s_a}{t_R} \cdot k_v \cdot MP1511$$

F_{zus} = additional feed rate [m/min]
Δs_a = following error difference after one control loop cycle [mm]
t_R = control loop cycle time [µs]
k_v = control loop gain [(m/min)/mm]
MP1511.x = factor for static friction compensation [µs]

This additive nominal value is limited with MP1512.x. If this limit is too high, the machine vibrates while at standstill:

$$MP1512.x = \frac{s_{agrenz} \cdot 256}{TP}$$

MP1512.x = limitation of the amount of the static friction compensation [counting steps]
s_{agrenz} = limit value for Δs_a [µm]
TP = grating period of the encoder [µm]

Compensation

The compensation must be effective only at low feed rates, otherwise the nominal value increase will cause vibration at high velocity:

- In MP1511.x, enter a factor for static friction compensation (approximate value: 5000 to 10 000).
- In MP1512.x, enter a limit for the amount of the static friction compensation (approx. value: < 50).
- In MP1513.x, limit the maximum feed rate up to which the static friction compensation remains in effect.

MP1511.x **Factor for static friction compensation**
Input: 0 to 16 777 215 [µs]

MP1512.x **Limitation of the amount of the static friction compensation**
Input: 0 to 16 777 215 [counting steps]

MP1513.x **Feed-rate limitation for static friction compensation**
Input: 0 to 300 000 [mm/min]

MP1391 **Velocity feedforward control in the MANUAL and HANDWHEEL operating modes**
Format: %xxxxxxxxxxxxxx
Input: Bits 0 to 13 represent axes 1 to 14
0: Operation with following error (lag)
1: Operation with velocity feedforward control

Digital axes: Limitation of the integral factor

In machines with very high static friction, a position deviation at standstill can lead to the accumulation of a very high integral factor. This can lead to a jump in the position value when the axis “tears loose.” In such cases you can limit the integral-action component of the speed controller with MP2512.x.

MP2512.x **Limiting the integral factor of the speed controller**
Input: 0.000 to 30.000 [s] (realistically: 0.1 to 2.0)

6.4.7 Compensation of Sliding Friction (Only for Digital Axes)

Sliding friction is compensated within the range of the speed controller:

- With the integrated oscilloscope of the iTNC, define the nominal current value (I NOMINAL) at a very low speed of approx. 10 rpm.
- Enter the value for current in MP2610.x. At every change in direction, this amount is fed forward to the speed controller to compensate the sliding friction at low speeds.
- Measure the nominal value for current (I NOMINAL) at rated speed and enter it in MP2620.x. Depending on the speed nominal value, a certain current is fed forward to the speed controller and causes a sliding friction that depends on the speed.

When the traverse direction is reversed at high feed rates, the sliding friction might be overcompensated. In a circular interpolation test, such overcompensation appears in the form of reversal spikes that jut inward. With MP2612.x you can prevent overcompensation by delaying the compensation.

MP2610.x **Friction compensation at low speeds (effective only with velocity feedforward control)**
Input: 0 to 30.0000 [A]
0: No friction compensation (or axis is analog)

MP2612.x **Delay of the friction compensation (effective only with velocity feedforward control)**
Input: 0.0000 to 1.0000 [s] (typically: 0.015 s)
0: No friction compensation (or axis is analog)

MP2620.x **Friction compensation at rated speed**
Input: 0 to 100.000 [A]
0: No friction compensation (or axis is analog)

6.5 Tilting Axes

Swivel heads and tilting tables are often used on milling machines to machine workpieces from several sides.

The NC programs are written with a CAD system or directly at the iTNC using the **Tilt working plane** function. The user programs the part program in the X/Y plane and the iTNC interpolates the proper axes. All path functions, cycles, "datum setting" and "probing" can be applied in the transformed working plane.

6.5.1 Determining the Mechanical Offset

As an example, we will show how to determine the mechanical offset of a 45° double swivel head and of a forked swivel head.

Note

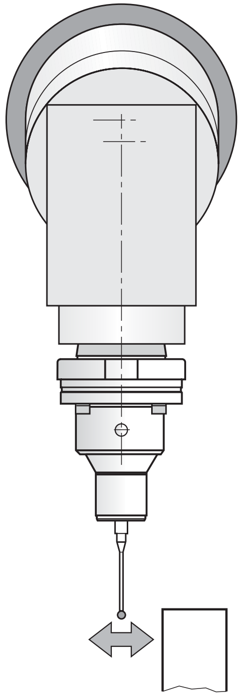
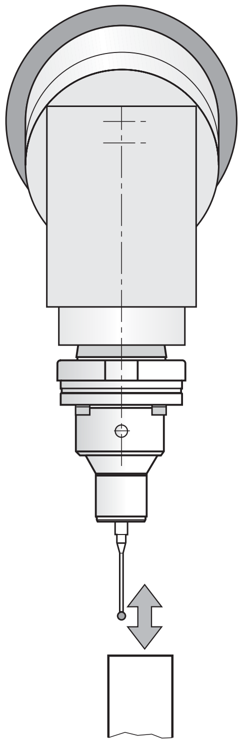
The 3-D ROT function must be inactive during the entire measuring process.

Double swivel head 45°

In this example, the mechanical offset of a double swivel head is determined by using a 3-D touch probe.

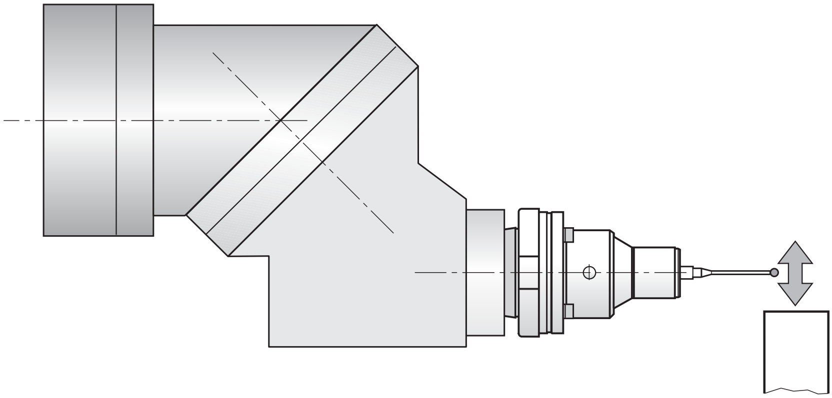
Input values for the machine parameters:

- MP7500 = %xxxx101
- MP7510.0 = %000100 ; Shift in Z axis
- MP7510.1 = %000001 ; Shift in X axis
- MP7510.2 = %001000 ; Rotate about A axis
- MP7510.3 = %000100 ; Shift in Z axis
- MP7510.4 = %100000 ; Free tilting axis C
- MP7510.5 = %001000 ; Rotate about A axis
- MP7510.6 = %000001 ; Shift in X axis
- MP7510.7 = %010000 ; Free tilting axis B
- MP7510.8 = %000000 ; End transformation

Step 1a ■ Move tilting axes B and C to 0° position ■ Probe surface X1 ■ Set X = 0	
Step 1b ■ Probe surface Z ■ Set Z = 0	

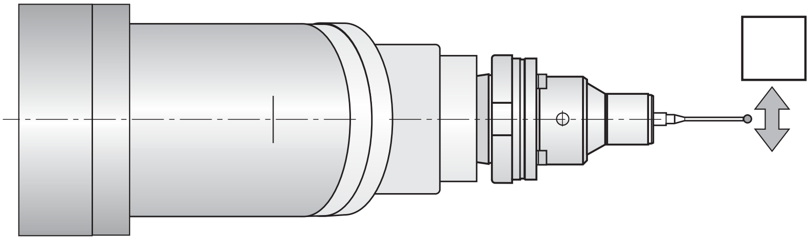
Step 2

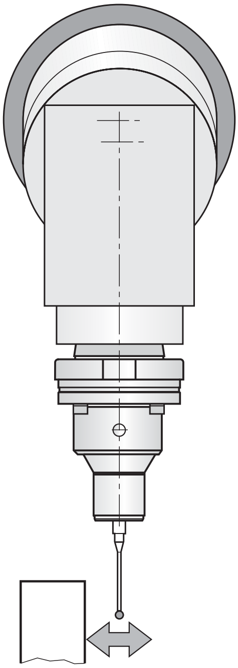
- Position C = 180
- Probe surface Z
- MP7530.0 = determined value – probe length + ball radius



Step 3

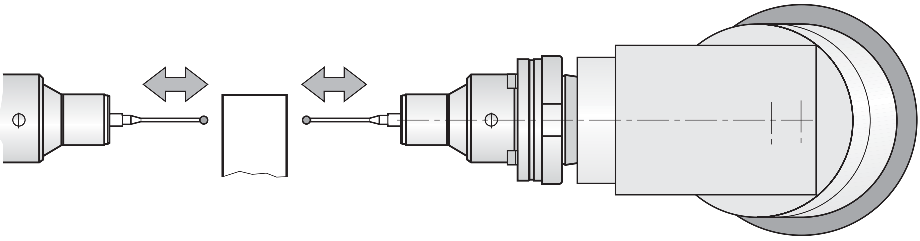
- Probe surface X1
- MP7530.1 = -0.5 * determined value



Step 4a	
■ Position C = 0 ■ Probe surface X2 ■ L = determined value	

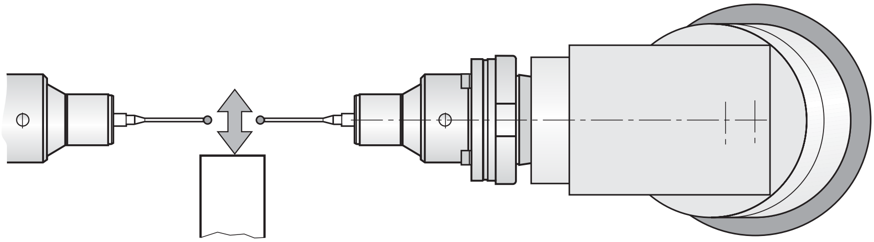
Step 4b

- Position B = -90
- Probe surface X1
- ΔX1 = determined value
- Position B = +90
- Probe surface X2
- ΔX2 = determined value
- MP7530.3 = {[0.5 * (ΔX2 – ΔX1 – L – 2*(probe length) + 2*(ball radius))] – MP7530.0} / cos 45°



Step 4c

- Position B = -90
- Probe surface Z
- Set Z = 0
- Position B = +90
- Probe surface Z
- MP7530.6 = –0.5 * determined value – MP7530.1

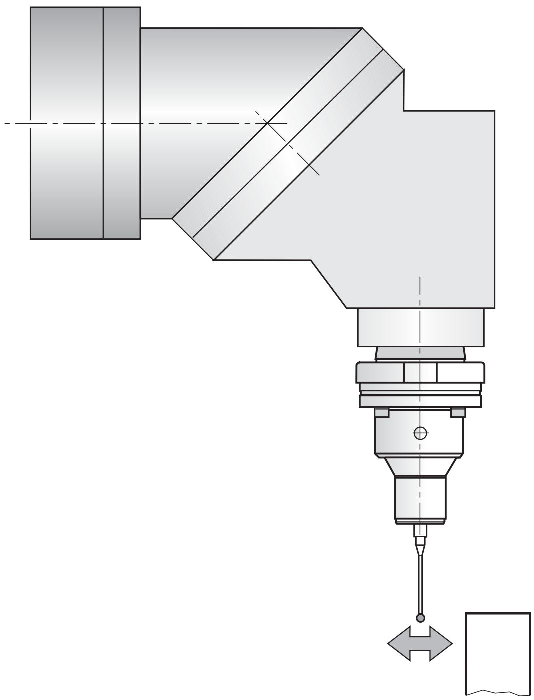


Step 5

- Probe surfaces X1, X2, Y2 and Z in a tilted working plane with the tilting angles B = –90, B = +90 and C = 180 (with MP7500 = %xxxxx0x)
- If there are differences between the individual tilting angles, the offsets from MP7530.0 and MP7530.3 should be determined with a different process (steps 6 to 8), and the averages from both processes should be entered in MP7530.0 and MP7530.3.

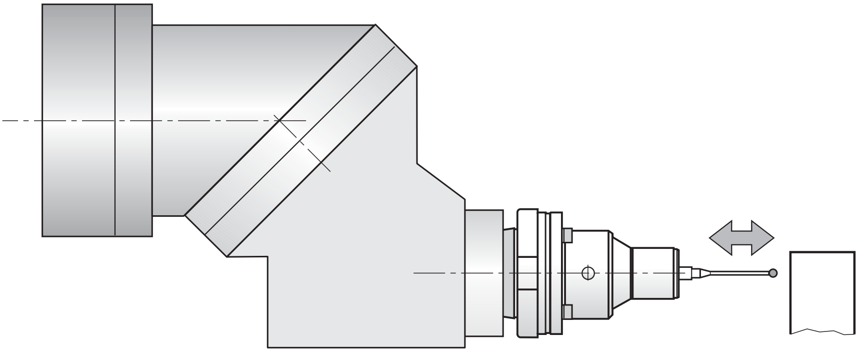
Step 6

- Probe surface Y2
- Set Y = 0



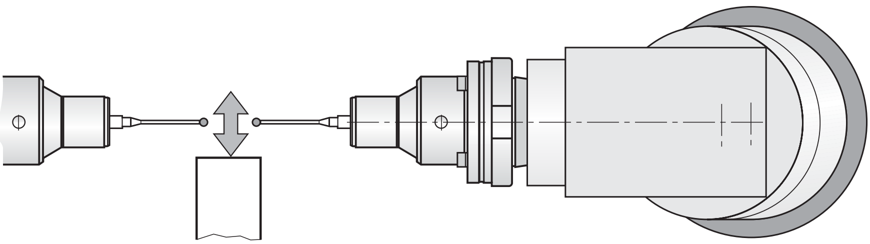
Step 7

- Position C = 180
- Probe surface Y2
- ΔY2 = determined value
- Z1 = ΔY2 – probe length + ball radius
- If there is a difference between MP7530.0 and Z1, then MP7530.0 = 0.5 * (MP7530.0 + Z)



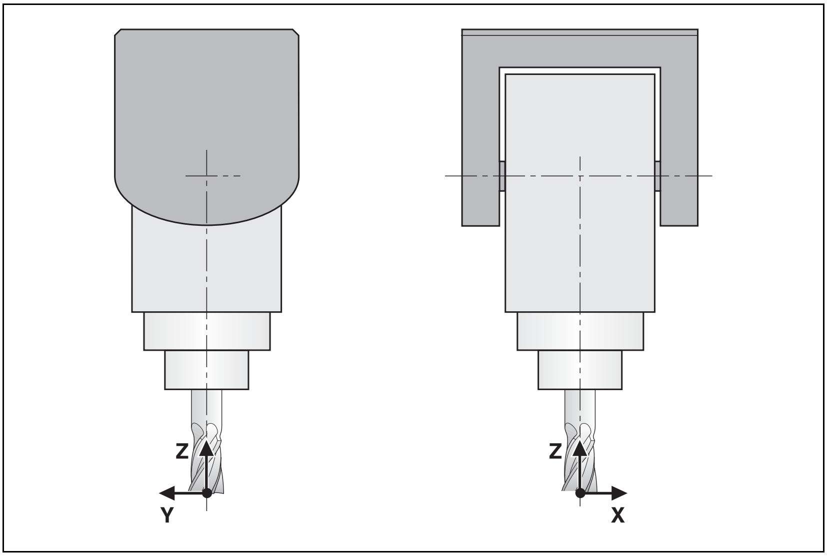
Step 8

- Position C = 0
- Position B = -90
- Probe surface Z
- ΔZ = determined value
- Position B = +90
- Probe surface Z
- Z = {[–0.5 * (ΔZ + determined value) – probe length + ball radius] – Z1} / cos 45°
  (Z1 see step 7)
- If there is a difference between MP7530.3 and Z, then MP7530.3 = 0.5 * (MP7530.3 + Z)



Forked swivel head

In this example, the mechanical offset of a forked swivel head is determined with a dial indicator and a cylinder with a known diameter.



Temporary input values for the machine parameters:

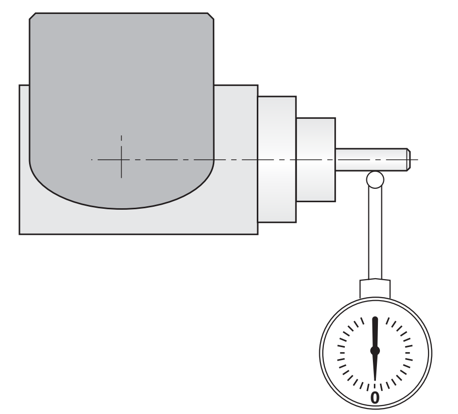
- MP7500 = %xxxx101
- MP7510.0 = %000100 ; Shift in Z axis
- MP7510.1 = %000010 ; Shift in Y axis
- MP7510.2 = %001000 ; Free tilting axis A
- MP7510.3 = %000001 ; Shift in X axis
- MP7510.4 = %000010 ; Shift in Y axis
- MP7510.5 = %100000 ; Free tilting axis C

- MP7510.6 = %000000 ; End transformation

Step 1a

Determining the Y offset:

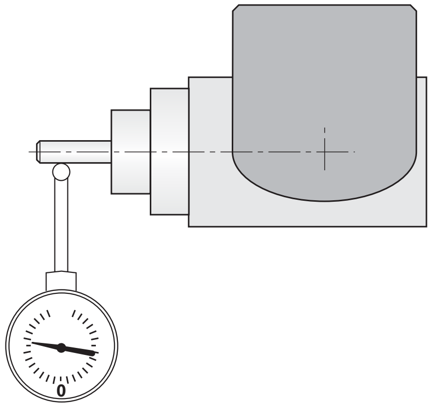
- Position A = -90
- Set the dial indicator to 0



Step 1b

Determining the Y offset:

- Position A = +90
- Offset = 0.5 * determined value
- If the determined value > 0, then MP7530.1 = **–** offset
- If the determined value < 0, then MP7530.1 = **+** offset



Step 1c

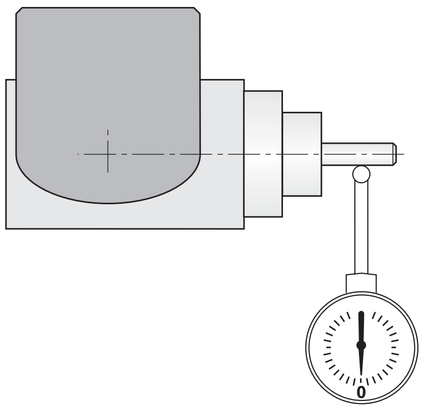
Checking the settings:

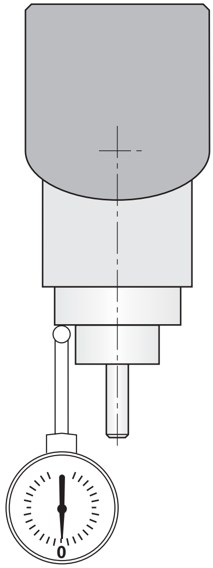
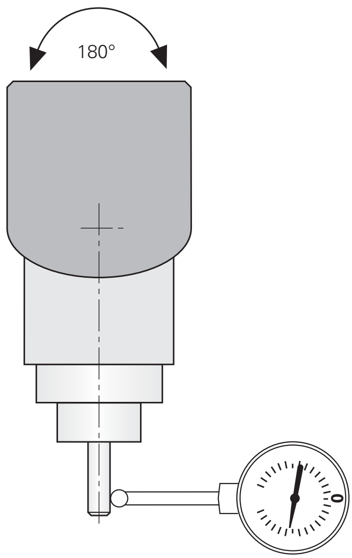
- Activate 3-D ROT
- Position A = +90
- Set the dial indicator to 0
- Set datum
- Position A = -90
- Probe same position again
- Display and dial indicator must read 0

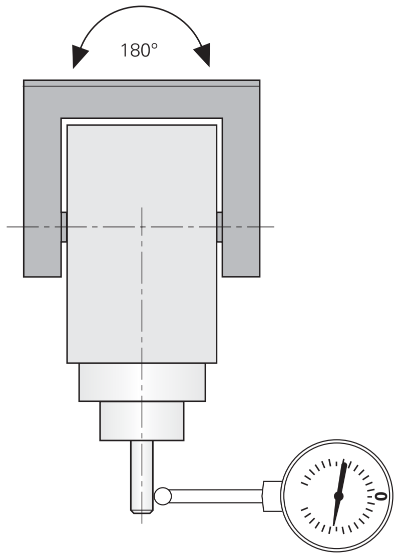
Step 2a

Determining the Z offset:

- Position A = -90
- Set the dial indicator to 0
- Set the Z display = 0



Step 2b Determining the Z offset: ■ Position A = 0 ■ Place dial indicator against the spindle nose ■ **MP7530.0** = displayed value – cylinder radius	
Step 3 Determining the Y offset: ■ Position A = 0 ■ Position C = 0 and set C = 0 ■ Position C = 180 ■ Read Y offset from the dial indicator ■ **MP7530.4** = (0.5 * determined value) – MP7530.1	

Step 4	
Determining the X offset: ■ Position C = –90 and set C = 0 ■ Position C = 180 ■ Read X offset from the dial indicator ■ MP7530.3 = 0.5 * determined value	

6.5.2 Describing the Mechanical Offset

> **Note**
>
> The description of the mechanical offset is only taken into account for tilting functions, such as M128 or the "tilted working plane" function.

Describing the mechanical offset

Determine the mechanical offset of the axes in the home position. For swivel heads, the starting point is the tool datum; for tilting tables, the starting point is the center of rotation of the first axis (as seen from the workpiece):

- Only for tilting tables: Define the center of rotation of the first tilting axis with respect to the machine datum.
- Determine in sequence the linear or rotary offset to the next tilting axis until you reach a point that is not separated from the machine frame by any free tilting axis.
- In MP7510.x, enter the sequence of the transformed axes, in MP7520.x the type of axis and dimensional data, and in MP7530.x enter the value of the offset. See the examples on the following pages.
- In MP7550.x, enter the home position of the tilting device in the machine coordinate system.

If a rotation has been entered, it must be canceled again in an additional transformation.

As a rule, the control takes changes in the mechanical offset into account, meaning that these changes do not have to be compensated with a PLC datum shift.

Describing the mechanical offset with tables

In order to manage several descriptions of the mechanical offset, e.g. when swivel heads are changed, the descriptions can be saved in tables. A description is activated either by the PLC or the NC.

Two types of tables are required:

Assignment table
Each row corresponds to one description (row 0 = description no. 1, etc.). The first column contains the line number. For each description (= row), the value of MP7500 for the description is entered in column two. Keep in mind that the value must be entered as a decimal number. The file name with its complete path is entered in the third column.

Description tables
The description table contains the contents of machine parameters MP7510.x, MP7520.x, MP7530.x and MP7550.x. The index x corresponds to the line number.
Of course the MP7530 column may also contain formulas, such as temperature compensation with M128, etc. See page 6 – 74. A formula for a permanently effective temperature compensation may be entered in the TEMPCOMP column. See page 6 – 75.

Working with the description of the mechanical offset in tables:

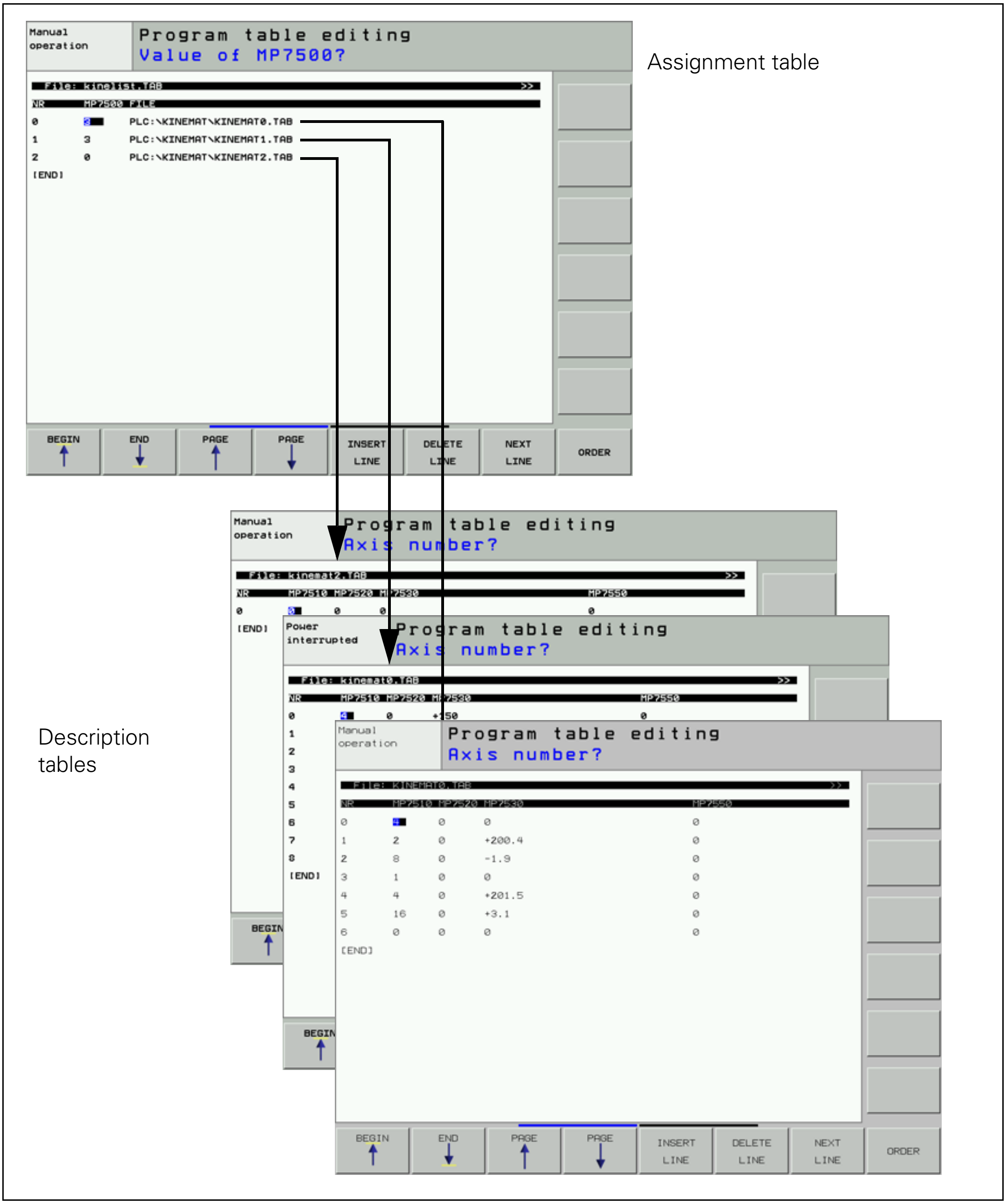
- Switch to the **`Programming and Editing`** operating mode, press the MOD key and enter the code number 807667.
- Choose the file PLC:\OEM.SYS from within program management.
- Enter the code word **`KINEMATIC=`** , followed by the file name with its complete path from the assignment table.
  (e.g., **`KINEMATIC= PLC:\KINEMAT\KINELIST.TAB`**)
- Leave OEM.SYS by pressing the END key.
- To create an assignment table: In program management, switch to the desired directory and enter the name of the assignment table, including the extension .TAB.
- Choose the table format with the MP7500, FILE and MPFILE fields.
- Enter the value from MP7500.x in the table for each description, and the path to the corresponding description table.
- To create a description table: In program management, switch to the desired directory and enter the name of the description table, including the extension .TAB.
- Choose the table format with the MP7510, MP7520, MP7530, MP7550 and TEMPCOMP fields.
- Enter the values of machine parameters MP7510.x, MP7520.x, MP7530.x and MP7550.x in the table.
- Activate the description table by transferring the row numbers from the assignment table
  - from the PLC with Module 9097
  - from the NC with **`FN17: SYSWRITE ID290 NR1`**
- You can ascertain the active description table in two ways:
  - With the PLC you can use Module 9098 to ascertain the name of the description table or the line number in the assignment table.
  - With the NC you can use **`FN18: SYSREAD ID290 NR1`** to ascertain the line number in the assignment table.

Note

The active description table is indicated with the status "M" in program management.

Time at which changes to the descriptions become effective:

- Swivel heads: when the corresponding description table is selected again.
- Tilting tables: when the corresponding description table is selected again **and** when a new datum is set.


Assignment table
Description tables
Manual operation
Program table editing
Value of MP7500?
File: kinelist.TAB
NR MP7500 FILE
0 3 PLC:\KINEMAT\KINEMAT0.TAB
1 3 PLC:\KINEMAT\KINEMAT1.TAB
2 0 PLC:\KINEMAT\KINEMAT2.TAB
[END]
BEGIN
END
PAGE
PAGE
INSERT LINE
DELETE LINE
NEXT LINE
ORDER
Manual operation
Program table editing
Axis number?
File: kinemat2.TAB
Power interrupted
Program table editing
Axis number?
File: kinemat0.TAB
Manual operation
Program table editing
Axis number?
File: KINEMAT0.TAB
NR MP7510 MP7520 MP7530 MP7550
0 4 0 0 0
1 2 0 +200.4 0
2 8 0 -1.9 0
3 1 0 0 0
4 4 0 +201.5 0
5 16 0 +3.1 0
6 0 0 0 0
[END]
BEGIN
END
PAGE
PAGE
INSERT LINE
DELETE LINE
NEXT LINE
ORDER

Example:

This example shows an assignment table for three description tables. The double swivel head 45° from example 2 was entered in the description table.

Assignment table KINEMATIC.TAB

```
NR      MP7500     FILE                    MPFILE       DOC
0       7          PLC:\KINEMAT1.TAB
1       7          PLC:\KINEMAT2.TAB
2       7          PLC:\KINEMAT3.TAB
[END]
```

Description table KINEMAT1.TAB

```
NR   MP7510  MP7520  MP7530           TEMPCOMP           MP7550
0    4       0       +150.5
1    8       0       –45
2    4       0       +251.5
3    32      0       0
4    8       0       +45
5    16      0       0
6    0       0       0
[END]
```

Module 9098 Finding the active geometry description

Module 9098 can find the name of the active description table and/or line number in the assignment table.

Call:

PS	B/W/D/K	<String number for table name> (line number is also determined) –1: Find only line number, no name
CM	9098	
PL	B/W/D	<Line number in the assignment table> –1: Line number not found

Error detection:

Marker	Value	Meaning
M4203	0	Name and/or line number was found
	1	Error code in W1022
W1022	2	Incorrect parameter for string number
	20	Module was not called in a submit job or spawn job

Module 9097 Selecting the geometry description

A geometry description from an assignment table can be chosen with Module 9097. The module can be called in a running NC program only in connection with a strobe. The module must be called in a submit job or spawn job, and cannot be cancelled with the CAN command.

Call:

PS	B/W/D/K	<Line number in the assignment table>
PS	B/W/D/K	<Mode, reserved> Transferred value must be 0
CM	9097	
PL	B/W/D	<Error condition> 0 = Geometry description was selected 1 = Invalid mode 2 = Line was not found in the assignment table 3 = Assignment table is not defined 4 = Description table does not exist 5 = Description table is incomplete 6 = Module was not called in a spawn job or submit job 7 = Call during running NC program without strobe 8 = No **KINEMATIC=** entry in the OEM.SYS file 9 = Error in the **MPFILE** column 10 = Error in the **MP7500** column 11 = Error in the machine parameter subfile

Error detection:

Marker	Value	Meaning
M4203	0	Geometry description was selected
	1	Error code in W1022
W1022	2	Invalid mode; or line was not found in the assignment table; or description table was not defined, does not exist or is incomplete; or there is no KINEMATIC= entry in the OEM.SYS file.
	9	Error in the MPFILE column
	10	Error in the MP7500 column
	11	Error in the machine parameter subfile
	20	Module was not called in a spawn job or submit job
	21	Call was made during a running NC program without a strobe

Compensation of offset of adapter spindle

It may happen that the current adapter spindle in the swivel head has a phase-angle error. This can be compensated as follows:

- Open the corresponding description table.
- Press the EDIT FORMAT soft key.
- Move the cursor to the END line and insert a new line by pressing the INSERT LINE soft key.
- Enter RAX_OFFS as **Field name**, C for **Field type**, 31 for **Field width**, 4 for the number of **decimal places** and a dialog text for the desired dialog languages, e.g. **OFFSET of angular axes?**
- Press the **END** key.

The new column RAX-OFFS has been added to the description table. In the first three lines of these columns, you can enter the phase-angle error of the adapter spindle.

- Line 0 corresponds to axis A
- Line 1 corresponds to axis B
- Line 2 corresponds to axis C

As soon as the description table has been activated, the phase-angle error is compensated.

Overwriting individual cells of the geometry description

Individual cells of the description table can be overwritten from within a machining program.

- Enter the code number 555343.
- Press the **SPECIAL TNC FUNCTIONS** soft key.
- Press the **ENTRY IN KINEMATIC TABLE** soft key.
- With the **WRITE TO KINEMATIC AT COLUMN <column to be written to> CAPTURE <searched column> KEY <keyword> =<value>** command you can overwrite individual cells in the active kinematics description in the Program Run operating modes. The line is selected by searching the **CAPTURE** column for the entry **KEY.** The column **COLUMN** is overwritten with **<value>.**

Selecting a geometry description in case of an error

In order for the machine operator to be able to select another geometry description in case of an error, abbreviations for the geometry descriptions can be entered in the **DOC** column of the assignment table.

To select another geometry description in case of an error:

- While in the **Programming and Editing** operating mode, press the MOD key.
- Enter the code number **KINEMATIC.**

A pop-up window appears with the abbreviation from the **DOC** column in the assignment table:

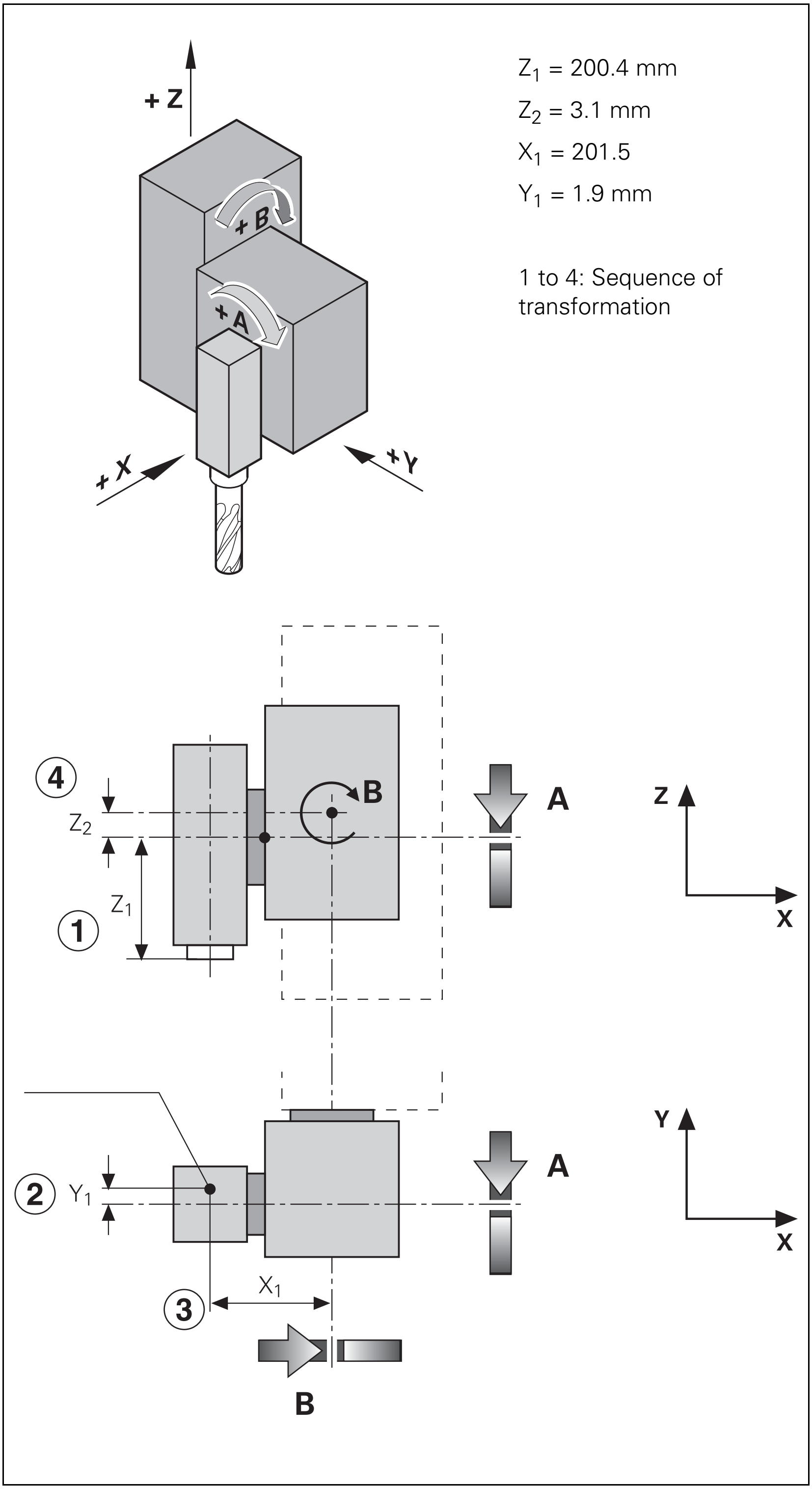
- Use the arrow keys to select the appropriate geometry description.
- Press the ENT key.

The control resets and activates the selected geometry description.

Note

As of NC software 340 422-03 and 340 480-03, more than 15 entries can be shown in the pop-up window.

Example 1: Rectangular double swivel head

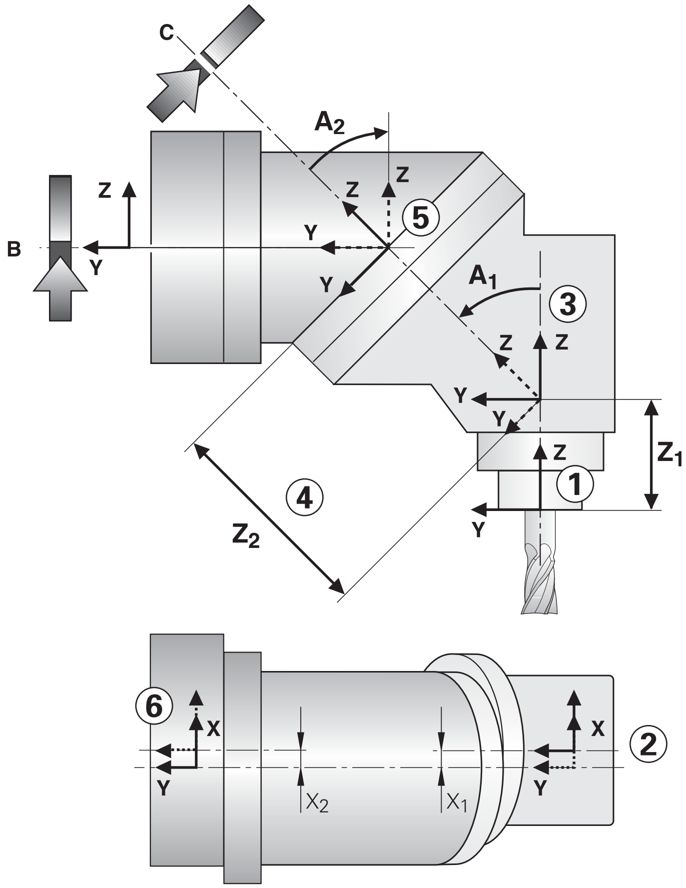


```
MP 7510.0   : %000100   ;Shift in Z axis (Z1)
MP 7510.1   : %000010   ;Shift in Y axis (Y1)
MP 7510.2   : %001000   ;Free tilting axis A
MP 7510.3   : %000001   ;Shift in X axis (X1)
MP 7510.4   : %000100   ;Shift in Z axis (Z2)
MP 7510.5   : %010000   ;Free tilting axis B
MP 7510.6   : %000000   ;End of the transformation chain

MP 7520.0   : %00       ;Incremental dimensions, swivel head
MP 7520.1   : %00       ;Incremental dimensions, swivel head
MP 7520.2   : %00       ;Incremental dimensions, swivel head
MP 7520.3   : %00       ;Incremental dimensions, swivel head
MP 7520.4   : %00       ;Incremental dimensions, swivel head
MP 7520.5   : %00       ;Incremental dimensions, swivel head

MP 7530.0   : +200.4    ;Dimension Z1
MP 7530.1   : -1.9      ;Dimension Y1
MP 7530.2   : +0        ;Variable dimension (free tilting axis A)
MP 7530.3   : +201.5    ;Dimension X1
MP 7530.4   : +3.1      ;Dimension Z2
MP 7530.5   : +0        ;Variable dimension (free tilting axis B)
```

Example 2: Double swivel head 45°



Z_1 = 150.5 mm

Z_2 = 251.5 mm

A_1 = 45°

A_2 = 45°

X_1 = 1.2 mm

X_2 = 0.8 mm

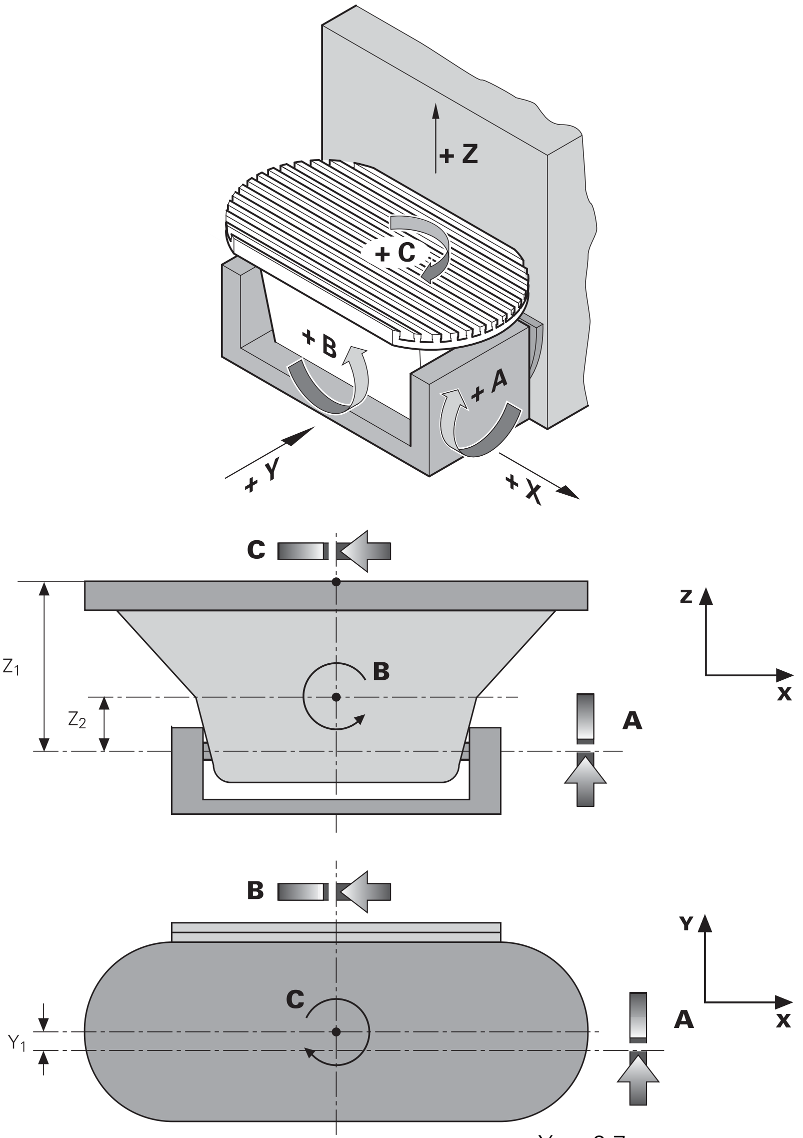
1 to 6: Sequence of transformation

```
MP 7510.0    : %000100    ;Shift in Z axis (Z1)
MP 7510.1    : %000001    ;Shift in X axis (X1)
MP 7510.2    : %001000    ;Rotate coordinate system about axis A (A1)
MP 7510.3    : %000100    ;Shift in Z axis (Z2)
MP 7510.4    : %100000    ;Free tilting axis C
MP 7510.5    : %001000    ;Rotate coordinate system about axis A (A1)
MP 7510.6    : %000001    ;Shift in X axis (X2)
MP 7510.7    : %010000    ;Free tilting axis B
MP 7510.8    : %000000    ;End of the transformation chain

MP 7520.0    : %00        ;Incremental dimensions, swivel head
MP 7520.1    : %00        ;Incremental dimensions, swivel head
MP 7520.2    : %00        ;Incremental dimensions, swivel head
MP 7520.3    : %00        ;Incremental dimensions, swivel head
MP 7520.4    : %00        ;Incremental dimensions, swivel head
MP 7520.5    : %00        ;Incremental dimensions, swivel head
MP 7520.6    : %00        ;Incremental dimensions, swivel head
MP 7520.7    : %00        ;Incremental dimensions, swivel head

MP 7530.0    : +150.5     ;Dimension Z1
MP 7530.1    : -1.2       ;Dimension X1
MP 7530.2    : -45        ;Dimension A1
MP 7530.3    : +251.5     ;Dimension Z2
MP 7530.4    : +0         ;Variable dimension (free tilting axis C)
MP 7530.5    : +45        ;Dimension A1
MP 7530.6    : +0.8       ;Dimension X2
MP 7530.7    : +0         ;Variable dimension (free tilting axis B)
```

Example 3:
Universal table
(pitch, tilt, rotation)



Y_1 = 2.7 mm

Z_1 = 331.3 mm
Z_2 = 125.9 mm

Coordinates (with respect to machine datum) of the center of rotation of table C when all tilting axes are in their home position:

X_R = 420.0 mm
Y_R = 151.2 mm
Z_R = –395.4 mm

```
MP 7510.0    : %000001    ;X coordinate of the center of rotation of
axis C
MP 7510.1    : %000010    ;Y coordinate of the center of rotation of
axis C
MP 7510.2    : %000100    ;Z coordinate of the center of rotation of
axis C
MP 7510.3    : %100000    ;Free tilting axis C
MP 7510.4    : %000010    ;Shift in Y axis (Y1)
MP 7510.5    : %000100    ;Shift in Z axis (Z1)
MP 7510.6    : %001000    ;Free tilting axis A
MP 7510.7    : %000100    ;Shift in Z axis (Z2)
MP 7510.8    : %010000    ;Free tilting axis B
MP 7510.9    : %000000    ;End of the transformation chain

MP 7520.0    : %11        ;Absolute dimension, tilting table
MP 7520.1    : %11        ;Absolute dimension, tilting table
MP 7520.2    : %11        ;Absolute dimension, tilting table
MP 7520.3    : %01        ;Tilting table
MP 7520.4    : %01        ;Tilting table
MP 7520.5    : %01        ;Tilting table
MP 7520.6    : %01        ;Tilting table
MP 7520.7    : %01        ;Tilting table
MP 7520.8    : %01        ;Tilting table

MP 7530.0    : +420       ;Dimension XR
MP 7530.1    : +151.2     ;Dimension YR
MP 7530.2    : -395.4     ;Dimension ZR
MP 7530.3    : +0         ;Variable dimension (free tilting axis C)
MP 7530.4    : -2.7       ;Dimension Y1
MP 7530.5    : –331.3     ;Dimension Z1
MP 7530.6    : +0         ;Variable dimension (free tilting axis A)
MP 7530.7    : +125.9     ;Dimension Z2
MP 7530.8    : +0         ;Variable dimension (free tilting axis B)
```

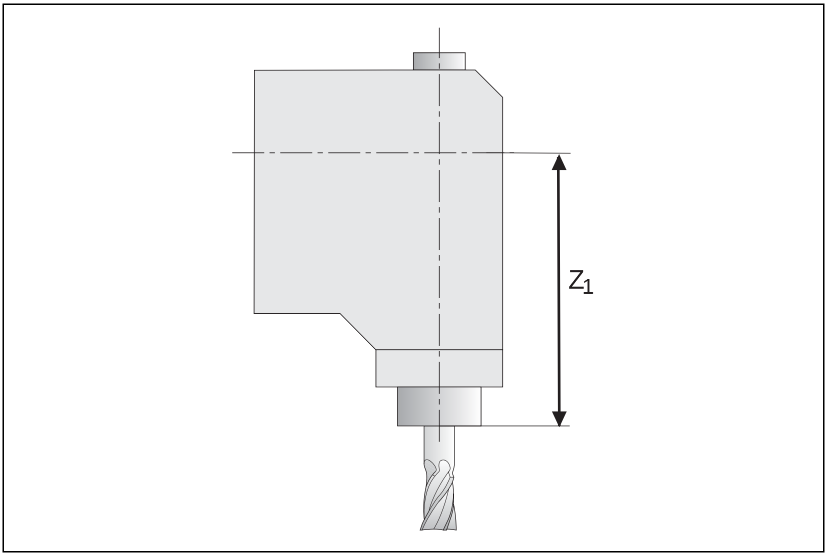
6.5.3 Temperature Compensation with Tilting Axes

A change in temperature always causes a change in length. For tilting axes, thermal growth of the spindle head must be compensated in the X, Y and/or Z axes.
There are two possibilities for temperature compensation:

- Temperature compensation with a "tilted working plane"
  - by entering a formula in MP7530.x
  - by entering a formula in the **MP7530** column of the description table
- Permanently effective temperature compensation
  - by entering a formula in the **TEMPCOMP** column of the description table

In most cases, the formula to be used will be the formula for calculating a change in length: $\Delta l = l \cdot \Delta T \cdot \alpha$
Δl: change in length
l: Length
ΔT: change in temperature
α: coefficient of expansion (steel: $11.5 \cdot 10^{-6}$ 1/K)

Example:



Z_1 = 300 mm (at 20 °C)
$\alpha_{steel} = 11.5 \cdot 10^{-6}$ 1/K (coefficient of expansion of steel)
W486: Temperature measured by a Pt100 thermistor

MP7530.x or TEMPCOMP = 300 + 300 * 11.5e–6 * (W486 – 20)
better: MP7530.x or TEMPCOMP = 300 + 3.45e–3 * (W486 – 20)

If the front part of the spindle gets warmer by 40 K, it results in a spindle length growth of

$$\Delta l = 300 \text{ mm} \cdot 40 \text{ K} \cdot 11,5 \cdot 10^{-6} \frac{1}{\text{K}} = 0,138 \text{ mm}$$

Constraints on the entry of a formula

- Maximum length of a formula: 31 characters
- Up to 16 variables in total
- Mathematical operations in lowercase letters, variables in uppercase letters
- The following operations are permitted in a formula:
  - Addition +
  - Subtraction –
  - Multiplication *
  - Division /
  - Logarithm to the base of 10 log10
  - Exponent ^
  - Parentheses ( )
  - Sine sin
  - Cosine cos
  - Tangent tan
  - Arc sine asin
  - Arc cosine acos
  - Arc tangent atan
  - Square root sqrt

An erroneous syntax of the formula is not recognized until the NC program is started. The error message **`MP75xx not defined`** appears.

Temperature compensation

If the "tilted working plane" function is active, the position of the tilting element is calculated for each positioning movement.
The variables are monitored every second, and if there are any changes, MP7530.x is recalculated.

> **Note**
>
> Remember that the changes are compensated with a certain delay. Positioning blocks that have already been calculated can no longer be considered.

Permanent temperature compensation

The permanent temperature compensation with the formula from the **TEMPCOMP** column is only effective if the description table is active. The algebraic sign of the compensation must match that of the axis error compensation in Words W576 to W584.
The variables are monitored every second and changes are reported to the position controller. The position controller uses the formula in the **TEMPCOMP** column and the current angle of the rotary axes to calculate the compensation values.
For temperature compensation, only rows with an entry in the **TEMPCOMP** column are considered, including the entry **0.** Any missing entry (NO ENT) interrupts temperature compensation at this point, meaning that the subsequent rows will not be taken into account. If rows 1 to 7 in the following example contained no entries instead of the entry **0,** the temperature compensation would only be applied to the Z axis. **The tilting axes would not be considered.** You can use this interruption of the temperature compensation to reduce processing time. For example, if a swivel head and tilting table follow each other in a table, but the temperature compensation is only to be applied to the swivel head. You would then make no entry for the tilting table in the **TEMPCOMP** column.
With Module 9040 or 9041, transfer value 8, the value of the temperature compensation can be determined.
The formula is only entered for the transformations where compensation is to occur.

Example of a description table with permanent temperature compensation for a 45° double swivel head:

NR	MP7510	MP7520	MP7530	TEMPCOMP	MP7550
0	4	0	+150.5	+150.5+1.73e–3*(W486-20)	0
1	1	0	–1.2	0	0
2	8	0	–45	0	0
3	4	0	+251.5	0	0
4	32	0	0	0	0
5	8	0	+45	0	0
6	1	0	+0.8	0	0
7	16	0	0	0	0
8	0	0	0		0
[END]					

6.5.4 Changing the Milling Heads

In order to change the milling heads, some new machine parameter values must be defined along with the new tilting axis geometry. For this purpose a machine parameter subfile can be entered in the **MPFILE** column. The machine parameter subfile contains the new axis configuration, the new axis motors, the assignments of the PWM outputs and the encoder inputs, etc. In this machine parameter subfile there must be no machine parameters that provoke a control reset:

- In the standard machine parameter file, the bits in MP10 need to be set to 1 for all possible axes.
- Switch off drives for the affected axes.
- Choose a row in the assignment table in which a machine parameter subfile is activated which sets the bits in MP10 to 0 for the affected axes. If the encoder of a **digital** axis needs to be disconnected, then the appropriate bit must also be set in MP20.x bit x = 0. In addition, MP2200.x = “ ” must be set.

Note

Encoders with EnDat interface must not be disconnected and reconnected during operation, since the absolute value is only read when the control is started up.

- Change the milling head.
- Choose a row in the assignment table which contains a machine parameter subfile for the new axes to set the bits in MP10 to 1 for the new axes. If an encoder on a digital axis was disconnected and reconnected, then MP20.x and MP2200.x must be correctly entered again.
- Switch on drive for the new axis/axes.
- After the drive has been switched on, the affected motors should make at least one revolution.

6.5.5 “Tilt Working Plane” Feature

The user defines the position of the working plane in Cycle 19 “Tilted Working Plane.” Then the iTNC performs a coordinate transformation.

With the 3D ROT soft key you can activate the tilted working plane separately for the MANUAL and PROGRAM RUN operating modes.

With MP7500 you can define the function of the tilted working plane cycle. With **`FN18: SYSREAD ID290 NR2`** you can request the values of the individual bits from MP7500.

Assignment of input values (Cycle 19)

With MP7500 bit 1 you define whether the input applies to the position of the tilted axes (bit 1 = 0) or the position of the working plane (bit 1 = 1).

If the input value applies to the position of the working plane, the iTNC calculates the position of the tilting axes and saves the coordinates in Q parameters:

- Q120: Coordinate of the A axis
- Q121: Coordinate of the B axis
- Q122: Coordinate of the C axis

With **`FN17:SYSWRITE ID990 NR5 IDX5`** you can determine if a principal axis is shown on top of another principal axis in an untilted coordinate system due to a tilt motion.

Automatic positioning

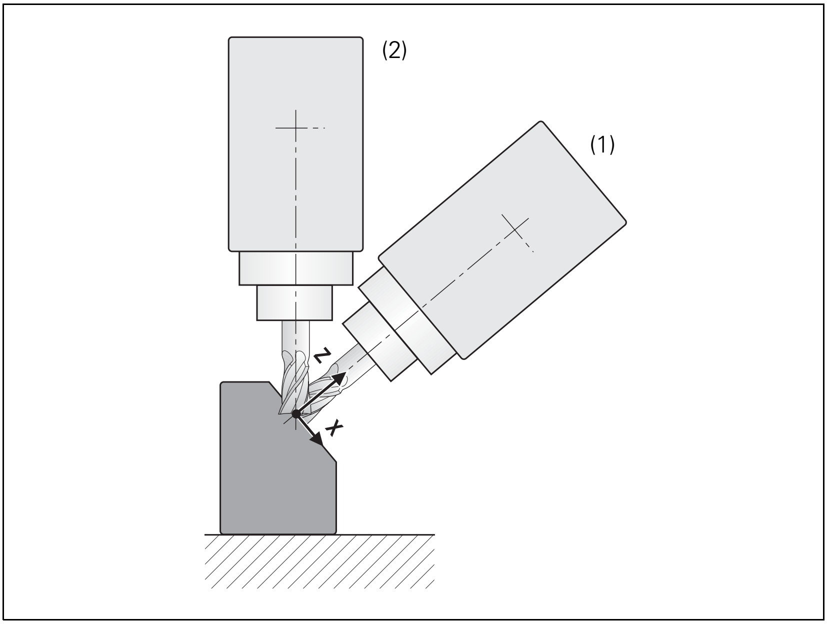
After the coordinate transformation, the Z axis remains parallel to the tool axis, perpendicular to the X/Y plane. With MP7500 bit 2 you define whether the “tilted working plane” function automatically positions the tilting axes (bit 2 = 1). In this case the user can enter the feed rate and setup clearance in the cycle.

The iTNC then moves automatically to the setup clearance and interpolates the swivel and principle axes so that the tool point remains in the same position in the tilted coordinate system.

Datums

Servo-controlled axes:

During “datum setting” for X, Y and Z, the datum is recalculated back to the home position of the tilting element when “tilted working plane” is **active** (1). So when “tilted working plane” is **inactive** and the tilting element is in its home position, the tool is positioned at the datum set while “tilted working plane” was **active.**



Behavior during datum setting can also be influenced via MP7500 bit 5:

MP7500 bit 5 = 0
During datum setting in X, Y and Z with an **active** tilted working plane, the current rotary-axis coordinates are checked to see if they are correct for the tilt angles, and with an **inactive** tilted working plane the rotary axes are checked to see if they are at 0. For datum setting with an **active** tilted working plane, the corresponding angles must be entered under 3-D ROT.

MP7500 bit 5 = 1
It can happen with titling elements with Hirth couplings that by locking the Hirth coupling, the actual value of the encoder will no longer exactly agree with the mechanical position of the tilting element. If this happens, the nominal values should be used to calculate the various datums (MP7682 bit 1).
If problems continue to occur, MP7500 bit 5 should be set to 1. The checking described in MP7500 bit 5 = 0 does not take place. The tilt angles entered under 3-D ROT are used to calculate the datums in X, Y and Z.

With MP7682 bit 1 you define whether the nominal or the actual values are used to calculate the presets during “datum setting” (is valid for MP7500 bit 5).

No servo-controlled axes:

The user must enter the current positions of the tilting axes by using the 3-D ROT soft key.

Note

In the combination of coordinate transformation cycles, note the sequence of activation and deactivation.

Spatial angle C ≠ 0

On machines with C tables and tool axis Z, the spatial angle C ≠ 0 (with A = 0 and B = 0) can be realized through a rotation of the coordinate system or a rotation of the table:

- With MP7500 bit 6 = 0, the spatial angle C is realized through a rotation of the coordinate system.
  With MP7500 bit 6 = 1, the spatial angle C is realized through a rotation of the table. At the same time, the angle is saved in Q122. This makes it possible, for example, to machine a workpiece by always using the same axis for paraxial linear blocks in the X/Y plane.

Conditions and constraints

Conditions:

- The display position in the status window is referenced to the tilted coordinate system.
- In the combination of coordinate transformation cycles the sequence of activation must agree with the sequence of deactivation.
- The tool radius compensation in the working plane and the tool length compensation parallel to the tool axis is active.
- For machining with tilting tables, the coordinate system remains parallel to the machine coordinate system.

Constraints:

- PLC positioning movements are always parallel to an axis of the machine coordinate system (Cycle 19 has no influence).
- A datum shift via PLC also works with the "tilted working plane" function.
- The axis designations for the tilting axes are limited to A, B and C. Each designation can be used only once.
- With an active Cycle 19 "tilted working plane," it is not possible to position with M91 or M92.

If the position of the working plane is entered, only the following swivel axes (with tool axis Z) are permissible:

- Double swivel head 45°: Axis sequence A fixed; B or C variable; A fixed; B or C variable
- Rectangular double swivel head: Axis sequence A or B variable; C variable
- Rotary or tilting table: Axis sequence C variable; A or B variable
- Swivel head and rotary table: Axis sequence A or B variable; C variable
- Swivel head 45°: Axis sequence C variable; A fixed; B variable; A fixed
- Rectangular double swivel head: Axis sequence A variable; B variable
- Universal swivel head: Axis sequence A fixed; B –90°; A variable; B +90°; A fixed; C variable
- Swivel head and rotary table: axis sequence B variable, A variable
- Swivel head and rotary table: Axis sequence C fixed, A fixed, B fixed –90°, A variable, B fixed +90°, A fixed, C variable

With tool axis Y:

- Rotary or tilting table: Axis sequence B variable; A variable
- Double swivel head 45° and rotary table: Axis sequence A fixed; C variable; A fixed; B variable
- Rotary or tilting table: Axis sequence A or C variable; A or C variable

With tool axis X:

- Universal swivel head: Axis sequence B fixed; A variable; B fixed; C variable

MP7500 **"Tilt working plane" (inactive preset table)**

Format: %xxxxxxxx

Input: Bit 0 – Switch-on "tilted working plane" function
0: Off
1: On
Bit 1 –
0: Angles correspond to the position of the tilting axes of the head/table
1: Angles correspond to the spatial angle (the iTNC calculates the position of the tilted axes of the head/table)
Bit 2 –
0: The tilting axes are not positioned with Cycle 19
1: The tilting axes are positioned with Cycle 19
Bit 3 –
0: The current tilting-axis position is taken into account with respect to the machine datum
1: The 0° position is assumed for the first rotary axis
Bit 4 –
0: Compensate mechanical offset during exchange of the spindle head when calling M128, M114 or "tilted working plane"
1: Compensate mechanical offset during PLC datum shift
Bit 5 –
0: The current tilting-axis position is taken into account with respect to the machine datum
1: The tilting-axis position that was entered with the 3-D ROT soft key applies
Bit 6 –
0: Spatial angle C is realized through a rotation of the coordinate system
1: Spatial angle C is realized through a rotation of the table.
Bit 7 –
0: The current tilting-axis position is taken into account with respect to the machine datum
1: The active tilting-axis position is
a) derived from the tilting angles in the 3D ROT window if manual tilting is active
b) derived from the reference coordinates of the rotary axes if tilting is inactive
Bit 8 –
0: The tilting axis positioning is considered depending on bit 3, bit 5 and bit 7
1: If manual tilting is active, the datum to be set for the principal axes X, Y and Z is recalculated back to the home position of the tilting element

MP7500 “Tilt working plane” (active preset table)

As of software version:340 422-01, 340 480-02

Format: %xxxxxxxx

Input: Bit 0 – Switch-on “tilted working plane” function
0: Off
1: On
Bit 1 –
0: Angles correspond to the position of the tilting axes of the head/table
1: Angles correspond to the spatial angle (the iTNC calculates the position of the tilted axes of the head/table)
Bit 2 –
0: The tilting axes are not positioned with Cycle 19
1: The tilting axes are positioned with Cycle 19
Bit 3 – No function
Bit 4 – No function
Bit 5 – Test of the tilting axis during “datum setting” in X, Y and Z
0: Current tilting-axis position must fit to the defined tilting angles
1: No test
Bit 6 –
0: Spatial angle C is realized through a rotation of the coordinate system
1: Spatial angle C is realized through a rotation of the table.
Bit 7 – No function
Bit 8 – No function

MP7510 Transformed axis

Format: %xxxxxx

Input: 0: End of the transformation sequence
Bit 0 corresponds to axis X
Bit 1 corresponds to axis Y
Bit 2 corresponds to axis Z
Bit 3 corresponds to axis A
Bit 4 corresponds to axis B
Bit 5 corresponds to axis C

MP7510.0–14 Transformation 1 to transformation 15

MP7520 Additional code for transformation

Format: %xx

Input: Bit 0 – Tilting axis
0: Swivel head
1: Tilting table
Bit 1 – Type of dimension in MP7530
0: Incremental dimension for swivel head
1: Absolute with respect to the machine datum for tilting table

MP7520.0–14 Transformation 1 to transformation 15

MP7530 **Type of dimension for transformation**
Input: -99 999.9999 to +99 999.9999
0: Free tilting axis
MP7530.0–14 Transformation 1 to transformation 15

Note

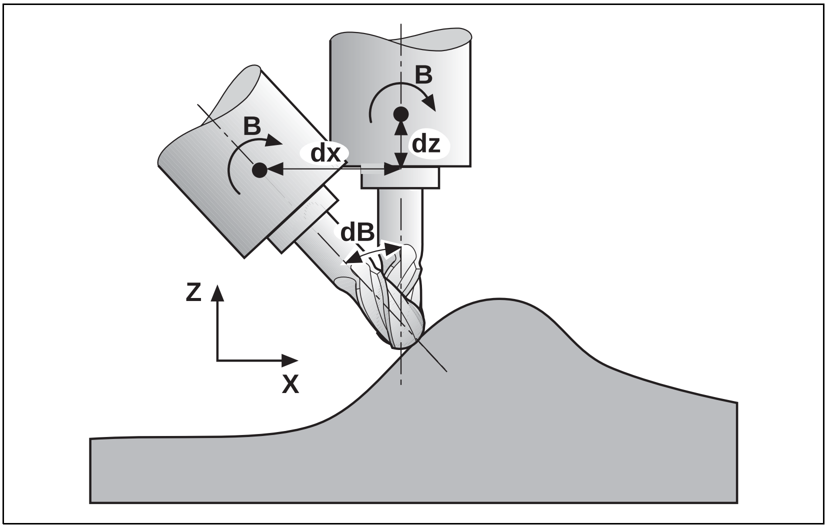
MP7530 cannot be overwritten with Module 9031 (overwrite machine parameters), since the MP contains a string, but the module transfers an integer value.

MP7550 **Home position of the tilting element**
Input: -99 999.9999 to +99 999.9999
MP7550.0 A axis
MP7550.1 B axis
MP7550.2 C axis

MP7682 **Machine parameter with multiple function**
Input: Bit 1 – Reference value for calculating the preset during "datum setting"
0: Actual value is calculated
1: Nominal value is calculated

6.5.6 Automatic Compensation of Offset for Tilting Axes

Unlike the "tilted working plane," here the coordinate system is not tilted. With M114 or M128, the iTNC compensates the offset of the tool that results from tilting the axes. The tool tip is always located on the programmed nominal coordinates.



The iTNC can perform a 3-D length compensation; the radius compensation must be performed by the CAD system or the postprocessor. If the iTNC compensates the tool length, then the programmed feed rate refers to the tool point. Otherwise it refers to the tool datum.

Miscellaneous function M114

Automatic compensation with M114:

- Linear and rotational movements are superimposed. The resulting contour deviations depend on the length of the linear interpolation.
- When the table is rotated, the coordinate system is rotated against the machine coordinate system. The iTNC **does not take this into account.**
- M114 can be used with non-controlled tilting axes or PLC tilting axes. In this case, the current tilting angle and the tilting axis are entered in the NC block behind M114.

Miscellaneous function M128

Automatic compensation with M128:

- Linear and rotational movements are superimposed. The resulting contour deviations are compensated.
- When the table is rotated, the coordinate system is rotated against the machine coordinate system. The iTNC **takes this into account.**
- M128 remains in effect even after a change in operating modes. This means that the axis can be moved with the compensated machine geometry in Manual mode with the axis direction keys, or in the Handwheel mode.
- With the miscellaneous function M118, the handwheel positioning movements can be superimposed on the program run movements. The iTNC automatically performs the compensating movements in the principal axes.

A transitional element is inserted at non-tangential contour transitions when positioning with rotary axes. However, W1026 (axes in position) is not set and axes will not be clamped. This problem can be solved with M134 (Exact stop at non-tangential contour transitions when positioning with rotary axes):

▶ Program M134 in the NC program or set MP7440 bit 6 = 1.

When M128 is used, the principal axes make compensating movements:

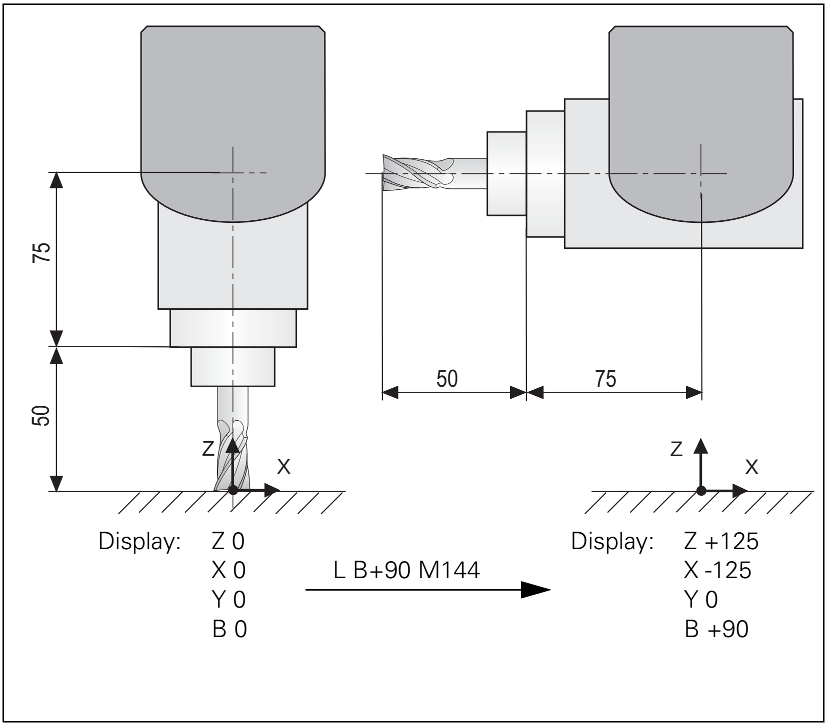
▶ In MP7471, define the maximum velocity of the principal axes during compensating movements.

▶ In MP7684 bits 5 and 6, set how the compensatory movements of the reference axes are to affect the feed-rate reduction at corners with M128.

MP7440	**Output of M functions**
Format:	%xxxxxxx
Input:	Bit 6 – Automatic activation of M134 0: M134 must be activated in the NC program 1: M134 is automatically activated when an NC program is selected.
MP7471	**Maximum velocity of the principal axes during compensating movements through M128**
Input:	0 to 300 000 [mm/min]
MP7684	**Nominal position value filter and path control with M128**
Format:	%xxxxxxxx
Input:	Bit 5 - Feed-rate reduction at corners with M128 0: Include only maximum compensatory movement 1: Do not include compensatory movements Bit 6 - Feed-rate reduction at corners with M128 0: Include compensatory paths depending on the entry in bit 5 1: Include all compensatory paths

Miscellaneous function M144/ M145

With M144 the movement of a tilted axis is recorded in the display. There is no need for the axes to traverse a compensatory path. M144 is deactivated with M145.



`FN18: SYSREAD ID310 NR144` can determine if M144 is active or inactive.

MP7502 **Functionality of M144/M145**

Input: %xxx
Bit 0
0: M144/M145 not active
1: M144/M145 active
Bit 1 – M144/M145 in the automatic modes
0: M144/M145 active
1: M144 is activated automatically at the start of an NC program. It can only be deactivated with M145 during an NC program.
Bit2 – M144/M145 in the manual modes
0: M144/M145 not active
1: M144/M145 active

6.5.7 Cylindrical Surface

Cycles 27 and 28, “Cylinder Surface,” enable the user to machine a contour on a cylindrical surface (see the User’s Manual).

Prerequisites:

- In MP7510 to MP7530, the center of rotation of a rotary axis must be defined (see example 3). MP7500 is not needed if only one rotary axis is present.
- If a PLC datum compensation is used, the same home position must apply in the description of the machine geometry in MP7510.x to MP7530.x as in the datum shift.
- After a change in MP7510.x or MP7530.x, the datum must be reset.

6.6 Synchronized Axes

6.6.1 Gantry Axes

In gantry axes, tandem tables, etc., two servo-controlled axes are coupled so that they can only move simultaneously. The main axis is referred to as the master, and the tracking axis as the slave. From a maximum of nine controlled axes, four times two axes can be controlled synchronously.

The function is effective during control both with following error and with velocity feedforward.

Activating synchronized axes:

▶ Assign a slave axis to a master axis.

MP850.x **Synchronized axes**
Input: 0: Master axis
1: Slave axis to axis 1
2: Slave axis to axis 2
3: Slave axis to axis 3
4: Slave axis to axis 4
5: Slave axis to axis 5
6: Slave axis to axis 6
7: Slave axis to axis 7
8: Slave axis to axis 8
9: Slave axis to axis 9

Example

Axis 4 is slave to axis 1:

- MP850.0 = 0
- MP850.1 = 0
- MP850.2 = 0
- MP850.3 = 1
- MP850.4 = 0
- MP850.5 = 0
- MP850.6 = 0
- MP850.7 = 0
- MP850.8 = 0

Master-slave position deviation

The iTNC monitors the synchronism of the coupled axes. If the master and slave axes deviate from each other by the difference of the following errors, the iTNC displays the slave axis with the message **EXCESSIVE SERVO LAG IN <AXIS>.** The LAG display shows the current difference in position.

▶ In MP855.x of the slave axis, enter the maximum permissible difference in positions between the master and slave.

If an offset is caused in the axes through an emergency stop, they will be synchronized after the emergency stop.

Datum at position after switch-on (MP860.x = 0)

Entry for the slave axis

With MP860.x you can select whether the position after switch-on should be used as a synchronization reference. Master and slave axes must be at identical positions. If the defined datums are to be reproduced, then only the master needs to be moved over the reference mark.

Monitoring of synchronized axes begins immediately upon switch-on.

Datum at reference marks (MP860.x = 1)

Entry for the slave axis

With MP860.x you can select whether the position should be ascertained by traversing the reference marks. After crossing over the reference mark, the master and slave axes are positioned to the same value. The default setting can be corrected with MP960.x (machine datum). In order for MP960.x to be set, the axes must traverse the reference marks with MP860.x = 0, so that no compensation movements are made. An offset in the axes is corrected after both reference marks are traversed. Reference mark traverse is ended as soon as a reference mark is traversed in both axes. The monitoring function is not active until after the compensation movement. The monitoring function is not active before the reference marks are traversed.

Conditions:

- The same type of reference mark traverse must be set for both the master and slave axes (MP1350.x).
- The velocity with which an offset (after traversing a reference mark or emergency stop) is compensated for is defined in MP1330.x for the slave axis.
- In the sequence for traversing the reference marks (MP1340.x), the master axis must be defined before the slave axis.
- The compensation movement can **not** be stopped with an NC stop (only with an emergency stop).
- The compensation movement is **not** considered in the following words:
  - W1026 (Axes in position)
  - W1028 (Axes in motion)
- If the master axis has traversed the reference mark at the time of an NC stop or an emergency stop, but the slave axis has not yet crossed it, then the slave axis can only be moved across it by using the axis-direction keys.
- Using a linear encoder: it is sufficient if the master axis has one reference end position.
- Using the speed encoder for linear measurement: One reference end position is enough, but the NC needs a reference end position signal for both axes (W1054).

Conventions

For synchronized axes:

- The slave axis cannot be moved separately.
- The nominal value display of the slave axis shows the nominal value of the master axis.
- The PLC program must ensure that the master axis does not move until the slave axis is ready (clamping, feed-rate enable).
- For the slave axis, the bits for traverse direction in W1030 and axis in motion in W1028 are **not** set.
- An axis cannot be both master and slave at the same time.
- Linear and nonlinear axis error compensation as well as temperature compensation must be entered separately for each axis.
- The values for rapid traverse, acceleration, jerk, software limit switches, feed rate for reference mark traverse, and manual feed rate are also taken over from the input values of the master axis for the slave axis.
- When operating with following error, the k_V factors for master and slave must be the same.
- The axes must be either both analog or both digital.
- Master and slave axes can be linear or rotary axes.

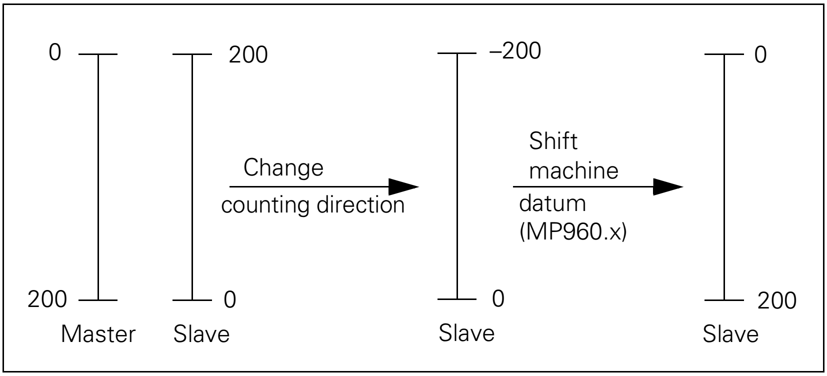
- For gantry axes, one position encoder is sufficient.
- The nonlinear axis-error compensation can be used separately for master and slave axes.
- For the nonlinear axis-error compensation, master and slave axes may be dependent on each other.

MP855.x **Synchronization monitoring**
Input: 0 to 100.0000 [mm]
0: Monitoring not active

MP860.x **Datum for synchronous control**
Input: 0: Datum at position after switch-on
1: Datum at reference marks

Example

- Gantry axes with two position encoders
- Position encoder of the slave axis is mounted mirror-inverted.



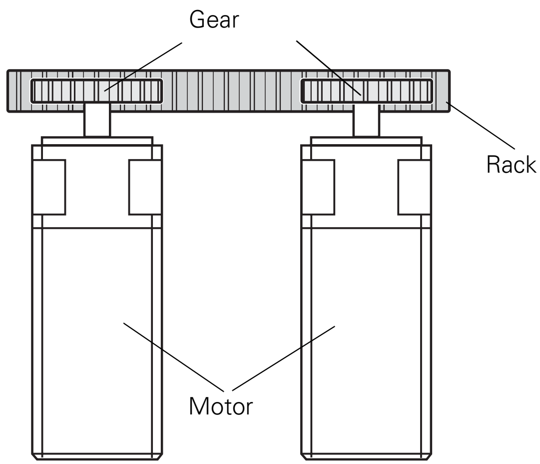
6.6.2 Master-Slave Torque Control

In master-slave torque control, two motors (master and slave) are mechanically coupled. Because of the coupling, only one position encoder is required. The motor to which the position encoder is assigned is the master.

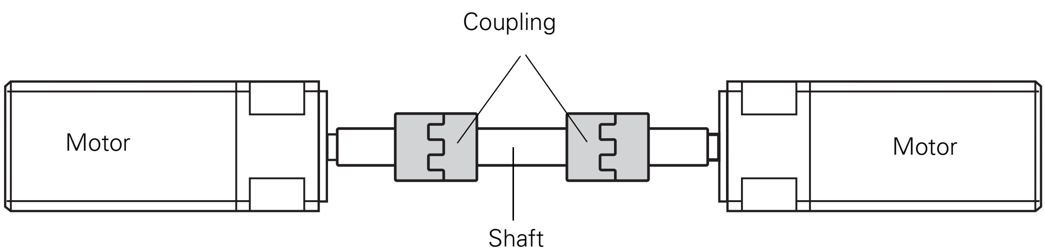
From a maximum of nine controlled axes, four times two axes can be controlled in the torque-master-slave-control, whereby you must keep in mind that the master and slave axis are on the same speed controller PCB.
First speed controller PCB: X15 to X20
Second speed controller PCB: X80 to X85

In principle there are two applications:

- Minimization of mechanical play through mutual tensioning
- Distribution of torque with a rigid coupling



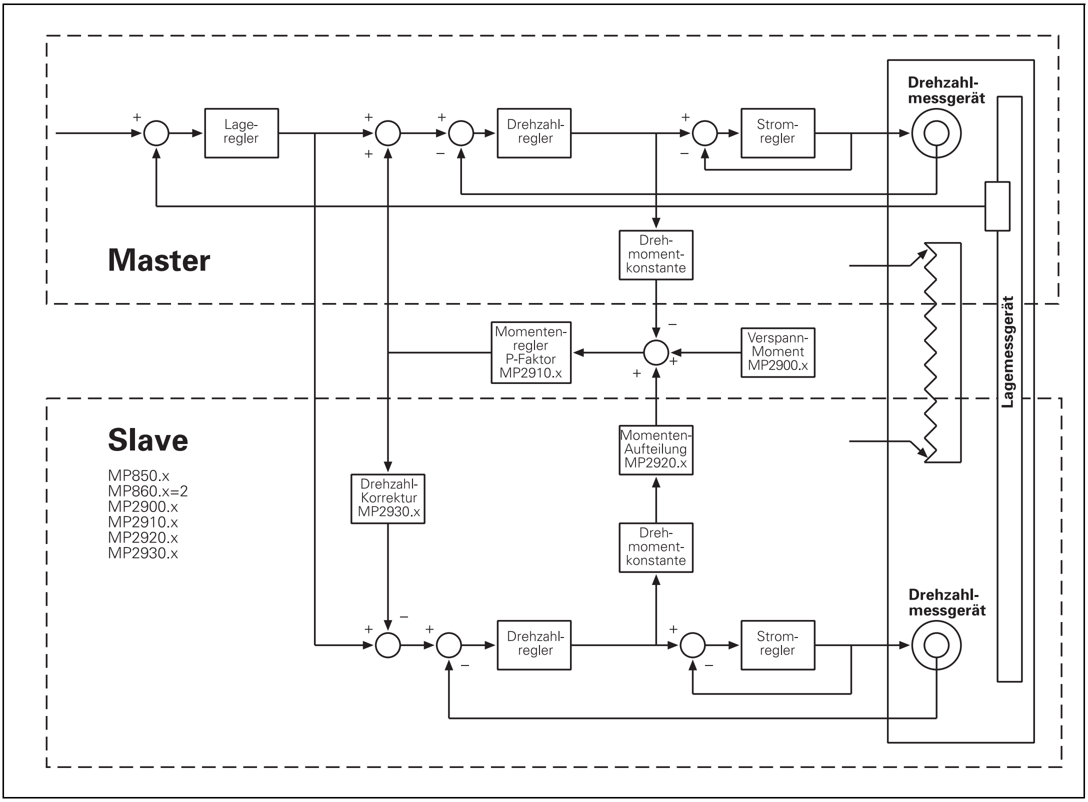
Minimization of mechanical play through mutual tensioning



Distribution of torque with a rigid coupling

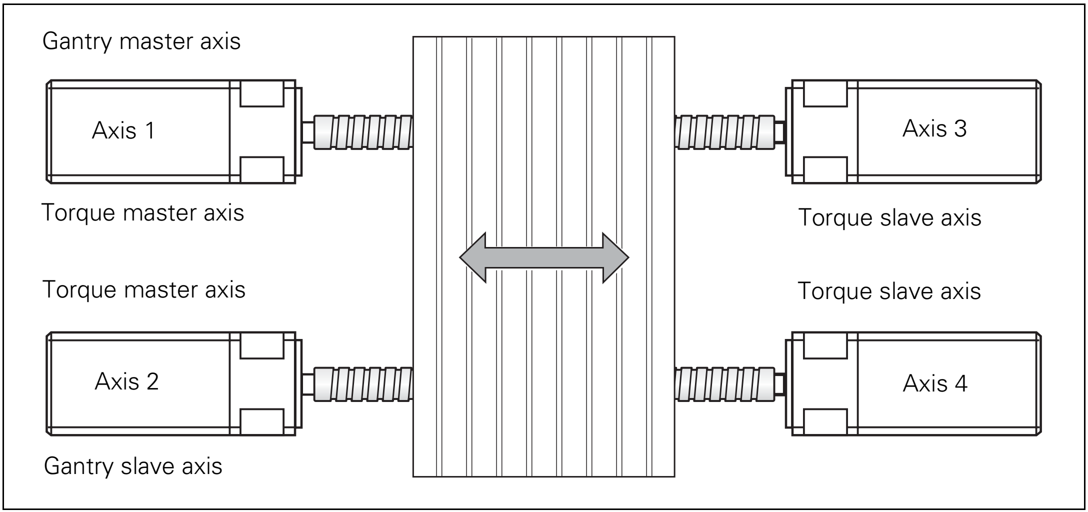
Method of function

Position control is deactivated in the slave axis. The nominal velocity of the master axis is at the same time the nominal velocity of the slave axis. The speed controllers of both axes remain independent. The manipulated variables coming from the speed controllers, i.e. the nominal torque current values, are weighted with the torque constants of the motors and compared with each other. In addition, a tensioning torque (MP2900.x) can be introduced at this comparison point. To permit a distribution of drive torque, the nominal torque of the slave axis can be multiplied with a weighting factor (MP2920.x). The result at the comparison point is fed to a torque balancing controller that amplifies it proportionally (MP2910.x). The manipulated variable of the balancing controller is a speed compensation value that is added to the current speed value.



Gantry axes in master-slave torque control

It is possible to run gantry axes in master-slave torque control. The gantry master and gantry slave axes are at the same time torque master axes and have one torque slave axis each.



Example for the MP entries:

MP850.0 = 0
Axis 1 is master axis

MP850.1 = 1
Axis 2 is slave to axis 1

MP850.2 = 1
Axis 3 is slave to axis 1

MP850.3 = 2
Axis 4 is slave to axis 2

MP860.0 = 0 or 1
Axis 1: Datum for synchronous control

MP860.1 = 0 or 1
Axis 2: Datum for synchronous control

MP860.2 = 2
Axis 3 is torque slave axis

MP860.3 = 2
Axis 4 is torque slave axis

Activation of master-slave torque control

- Activate the master and slave axes with MP10.
- In MP110.x, define the position encoder for the master.
- Enter MP110.x = 0 for the slave.
- In MP850.x, define the master axis as the main axis and the slave axis as the tracking axis.
- Activate the master-slave torque control by entering MP860.x = 2 for the slave axis.

MP860.x	**Datum for synchronous control**
Input:	2: Axis is torque slave axis

Setting the master-slave torque control for minimizing mechanical play

- For the master and slave axes you must select in MP1040 the same or the opposite direction of rotation, depending on the application (MP210 has no effect on the slave).
- Adjust the current controller for the master and slave axes. See "Commissioning" on page 6 – 234
- Enter the following temporary values in the machine parameters for the slave axis:
  MP2900.x = approx. 20% to 25% of the rated torque of the motor
  MP2910.x = 3
  MP2930.x = 0
- In MP2920.x, enter the ratio of the mass moment of inertia of the master to the mass moment of inertia of the slave. For identical motors, therefore, the value to be entered is 1.
- If you use a position encoder, enter 100 in MP2930.x for the slave axis; if you do not use a position encoder, enter the value 0.
- Enter MP2510.x (I factor of speed controller) = 50 or, if you have one, an empirical value for your motor.
- Adjust the P and I factor of the speed controller for the master and slave axes at the same time See "Commissioning" on page 6 – 234. It is not permissible to commission the master and slave axes separately, since the motors must be tensioned during commissioning.
- If you do not reach the desired rise time (approx. 10 ms), you can increase the P factor with the aid of a filter. Here the band-rejection filter is preferable to the low-pass filter.
- To find the center frequency for the band-rejection filter, slowly increase the P factor to the oscillation limit and find the frequency with the integrated oscilloscope.

Note

For low-frequency oscillations (< approx. 200 Hz) you should not use a filter, because it may have a negative influence on the dynamics of the control.
For the mid-range frequency (approx. 200 Hz to approx. 400 Hz) ensure that you do not excite any low-frequency oscillation.
The higher the frequency of the oscillation (> approx. 400 Hz), the less negative will be the influence of high damping on the dynamics.

Note

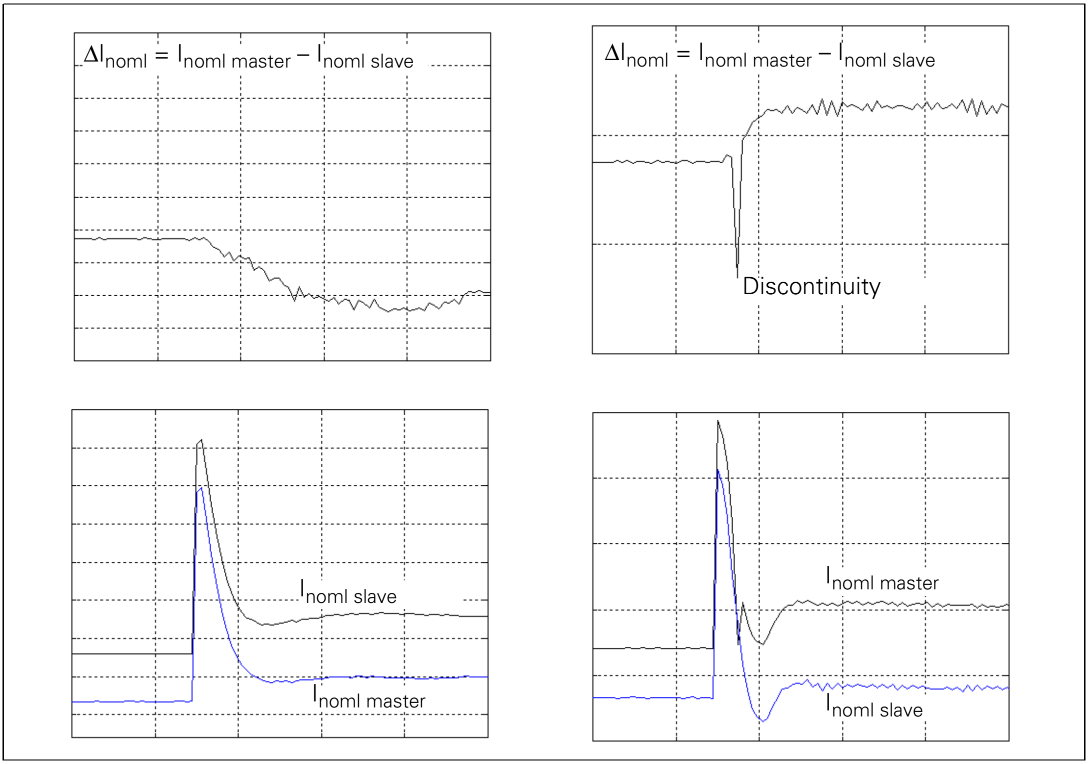
For identical motors, the factors of the speed controller should be identical to ensure identical dynamic behavior.

Test the tensioning torque:

▶ With the integrated oscilloscope, record the nominal current (I nominal) of the master and the slave axes at standstill.

▶ Send a step to the speed controller and, with the integral oscilloscope, record the nominal current of the master and slave axes.

▶ If there is a discontinuity in the course of the nominal current, increase the tensioning torque for the slave axis in MP2900.x.



Note

The lower the ratio of the total mass moment of inertia (transmission, machine table, etc.) to the motor mass moment of inertia, the smaller the required tensioning torque is (MP2900.x).

Test the P factor of the torque controller:

▶ With the integrated oscilloscope, record the actual speed value V (N ACTL).

▶ Increase the P factor in MP2910.x for the slave axis up to the oscillation limit.

▶ Enter in MP2910.x for the slave axis 50% of the resulting value.

Setting the master-slave torque control for torque distribution in a rigid design

- For the master and slave axes you must select in MP1040 the same or the opposite direction of rotation, depending on the application (MP210 has no effect on the slave).
- Adjust the current controller for the master and slave axes. See "Commissioning" on page 6 – 234.
- Enter the following temporary values in the machine parameters for the slave axis:
  MP2900.x = 0
  MP2910.x = 3
  MP2930.x = 0
- In MP2920.x, enter the ratio of the mass moment of inertia of the master to the mass moment of inertia of the slave. For identical motors, therefore, the value to be entered is 1.
- If you use a position encoder, enter 100 in MP2930.x for the slave axis; if you do not use a position encoder, enter the value 0.
- Enter MP2510.x (I factor of speed controller) = 50 or, if you have one, an empirical value for your motor.
- Deactivate the slave axis in MP10.
- For the master axis, adjust the P and I factor of the speed controller See "Commissioning" on page 6 – 234.
- If you do not reach the desired rise time (approx. 10 ms), you can increase the P factor with the aid of a filter. Here the band-rejection filter is preferable to the low-pass filter.
- To find the center frequency for the band-rejection filter, slowly increase the P factor to the oscillation limit and find the frequency with the integrated oscilloscope.

Note

For low-frequency oscillations (< approx. 200 Hz) you should not use a filter, because it may have a negative influence on the dynamics of the control. For the mid-range frequency (approx. 200 Hz to approx. 400 Hz) ensure that you do not excite any low-frequency oscillation. The higher the frequency of the oscillation (> approx. 400 Hz), the less negative will be the influence of high damping on the dynamics.

- Deactivate the master axis in MP10.
- Set MP850.x and MP860.x to 0 for the slave axis.
- Set the speed controller and the filter parameters for the slave axis in the same manner as for the master axis.

Note

For identical motors, the factors of the speed controller should be identical to ensure identical dynamic behavior.

Test the P factor of the torque controller:

- In MP10 reactivate the master and slave axes.
- With the integrated oscilloscope, record the actual speed value V (N ACTL).
- Increase the P factor in MP2910.x for the slave axis up to the oscillation limit.
- Enter in MP2910.x for the slave axis 50% of the resulting value.

MP2900.x **Tensioning torque between master and slave for master-slave torque control (entry for the slave axis)**
Input: -100.00 to +100.00 [Nm]

MP2910.x **P factor of the torque controller for master-slave torque control (entry for the slave axis)**
Input: 0.00 to 999.99 [1/(Nm · min)]

MP2920.x **Factor for variable torque distribution for master-slave torque control (entry for the slave axis)**
Input: 0.000 to 100.000
1: Master and slave axes have identical motors

MP2930.x **Speed compensation ratio for master-slave torque control (entry for the slave axis)**
Input: -100.00 to +100.00 [%]

6.7 Reference Marks

6.7.1 Definition

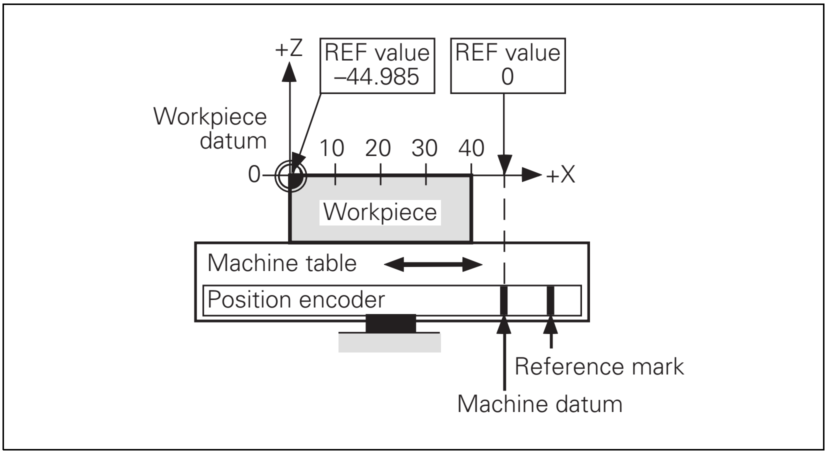
The position value (the coordinates) of an axis position is defined with respect to a freely selectable datum. When the axes are moved, the ACTUAL position is calculated incrementally. If there is an interruption in power, the reference between the axis position and the position value is lost.

Reference marks

HEIDENHAIN linear encoders are designed with one or more reference marks. The reference marks identify an axis position at a known distance from the machine datum. The position of the freely selectable datum is defined with respect to the machine datum.

The datum and the actual position can be reproduced as soon as the reference marks are traversed.

HEIDENHAIN recommends position encoders with distance-coded reference marks. With distance-coded reference marks, the position value can be reestablished after traverse of a short distance over any two reference marks.



6.7.2 Traversing the Reference Marks

The reference marks must be traversed after any interruption in power:

▶ Press the machine START button: The reference marks are automatically traversed. The sequence of axes is predetermined.

or:

▶ Press the machine axis-direction button. The user determines the sequence of the axes.

After the reference marks have been traversed:

- The software limit switches are activated.
- The most recently saved datum and machine datum are reproduced.
- PLC positioning and positioning with M91 and M92 become possible.
- The counter is set to zero for axes in an open loop.

Distance between the scale reference point and the machine datum

For distance-coded reference marks, the machine datum is defined with respect to the scale reference point, which is at the first reference mark after the beginning of the measuring length. On angle encoders, the scale reference point is marked.

▶ In MP960.x, enter the distance between the scale reference point and the machine datum.

For position encoders without distance-coded reference marks but with more than one reference mark, the distance between the reference mark to be traversed and the scale reference point must also be entered:

▶ With Module 9225, enter the distance between the reference mark to be traversed and the scale reference point.

Module 9225 Compensation value for the reference mark
With Module 9225 you define the distance between the reference mark to be traversed and the scale reference point for the NC and PLC axes.

Call:

PS	B/W/D/K	<Axis> 0 to 8: Axes 1 to 9 15: Spindle
PS	B/W/D/K	<Compensation value in 0.1 µm> 0: Reference mark to be traversed = scale reference point
CM	9225	
PL	B/W/D	<Error code> 1: Axis does not exist

Error detection:

Marker	Value	Meaning
M4203	0	No error
	1	Axis does not exist

Assigning a reference value

In some cases a new reference mark may have to be assigned to an axis, e.g. if an axis is mechanically fixed and the encoder is moved. Since due to the mechanical fixing the position of the axis cannot be changed, you can assign it a new reference value:

- Enter the new reference value in Module 9147.

Module 9147 Assigning a reference value to an axis

If a new reference value is assigned to an axis, the corresponding bit is reset in W1032.

Call:

PS	B/W/D/K	<Axis number>
		0 to 8: Axes 1 to 9
PS	B/W/D/K	<New reference value in 0.1 µm>
CM	9147	

Error detection:

Marker	Value	Meaning
M4203	0	No error
	1	Error code in W1022
W1022	2	Invalid axis number
	21	Missing strobe in M4176 = 1
	24	Module was called in a spawn job or submit job

Defining the process of traversing the reference marks

In machine parameters, you define the process of traversing the reference marks:

- In MP1320.x and MP1330.x (for rotary encoders also in MP1331.x) you define the direction and velocity for traversing the reference marks.
- In MP1340.x you define the sequence of axes for traversing the reference marks.
- With MP1350.x you select the type of reference marks.

External reference pulse

If it is not possible to use the reference mark of the encoder, for example due to an unsuitable transmission ratio between the motor and rotary axis, then you can use an external reference pulse:

- In MP4130.x, define the fast PLC input for the external reference pulse
- For the corresponding axis in MP1360.x, enter the number of the fast PLC input
- Enter MP1350.x = 6 for the corresponding axis

“Pass Over Reference Point” mode of operation

The NC uses W272 to report the “Pass Over Reference Point” operating mode to the PLC.

If you switch the operating mode before all reference marks are traversed, the PASS OVER REFERENCE soft key prompts you traverse the remaining reference marks. In W1032 the PLC receives the information as to which axes have not yet been referenced.
In W1032, the bits for axes that are not to traverse the reference marks (MP1340.x = 0) are reset.

In the NCMACRO.SYS file, after the code number RESETINIT= you can enter the name (incl. path) of a macro that will be called when the Pass Over Reference Point mode of operation is exited. If the NC macro is terminated once with END PGM or M02, it will no longer be run when the Pass Over Reference Point mode is called and exited.
To synchronize the current machine status and the look-ahead calculation with an NC macro call, See "NCMACRO.SYS" on page 9 – 24.

Reference end position

To prevent the axes from violating their traverse limits when traversing the reference marks, each axis requires a trip dog (at the reference end position). The trip dogs must be installed by the machine tool builder at the ends of the traverse range. The switch signals from the trip dogs are sent to free PLC inputs. The PLC program must gate these PLC inputs with W1054 for “reference end position.”

The axis will only automatically be positioned to the software limit switch if

- it is beyond the positive software limit switch and is moving in the positive direction to the positive trip dog.
- it is beyond the negative software limit switch and is moving in the negative direction to the negative trip dog.

Encoders with EnDat interface

Encoders with EnDat interface can be connected to the position and speed inputs of the MC 422 and CC 42x. With these encoders there is no need to traverse the reference marks. The position value is only read when the control is switched on. It cannot be read again.
When connecting a position encoder with an EnDat interface:

- Enter MP1350.x = 5.

When connecting a speed encoder with an EnDat interface:

- The iTNC automatically attempts to communicate with the encoder.

When connecting a speed encoder with an EnDat interface as a position encoder:

- Enter MP1350.x = 5.
- In MP110.x, enter 0 for the axis with the speed encoder with EnDat interface.

Note

If use of multiturn encoders with EnDat interfaces results in overruns, the corresponding information is entered in the system file NCDATA.SYS. For a control exchange, this file must be transferred or MP960.x must be readjusted.

Double reference run

During the double reference run, the absolute position is first output via the EnDat interface of the speed encoder. If at a later time the reference mark of the position encoder is traversed, the control continues to work with this reference.

▶ Set the corresponding bits in MP1355 to 1 for the axes for which the double reference run is to be used.

The distance between the speed encoder and the position encoder must be entered in MP1356.x. When the reference mark of the position encoder is **first** traversed, the message `Set MP1356.<axis number> to <value>` appears.

▶ Enter this value in MP1356.x.

Up to 340 422-04, 340 480-04: Depending on the position encoder being used, W1032 (reference marks not yet traversed) can have different meanings:

- Position encoder **with** distance-coded reference marks: After reading the absolute position via the EnDat interface, W1032 is reset for the affected axis.
- Position encoder **without** distance-coded reference marks: After reading the absolute position via the EnDat interface, W1032 remains set for the affected axis.

As of 340 422-05, 340 480-05:

▶ Define the behavior of W1032 in MP1357.x.

MP960.x **Machine datum**
Input: –1.79769313486E+308 to
+1.79769313486E+308 [mm] or [°]
Values with respect to the scale reference point

MP1320 **Direction for traversing the reference marks**
Format: %xxxxxxxxxxxxxx
Input: Bits 0 to 13 represent axes 1 to 14
0: Positive
1: Negative

MP1330.x **Velocity for traversing the reference marks**
Input: 80 to 300 000 [mm/min]

MP1331.x **Velocity for leaving the reference mark end position for axes 1 to 9 (only for rotary encoders MP1350 = 2)**
Input: 10 to 300 000 [mm/min]

MP1340.x **Sequence for traversing the reference marks**
Input: 0: No evaluation of reference marks
1 to 14: Axes 1 to 14

MP1350.x **Type of reference-mark traverse**

Input: 0: Linear encoder with distance-coded reference marks (old routine)
1: Position encoder with one reference mark
2: Special type (length measurement with ROD)
3: Linear encoder with distance-coded reference marks (new routine)
4: Same as 3 except that two reference marks are evaluated
5: Encoder with EnDat interface
6: Reference pulse over fast PLC input

MP1355 **Double reference run**

Format: %xxxxxxxxxxxxxx

Input: Bits 0 to 13 represent axes 1 to 14
0: Reference run as defined in MP1350.x
1: Double reference run

MP1356.x **Distance between speed and position encoder for double reference run.**

Input: -99 999.999 to +99 999.999 [mm] or [°]

MP1357.x **W1032 for double reference run**

Input: 0: Reset W1032 if the reference run has been over the EnDat interface of the speed encoder
1: Reset W1032 if the reference mark was traversed with the position encoder

MP1360.x **Fast PLC input for reference pulse**

Input: 0: No fast PLC input for reference pulse
1 to 5: Fast PLC input for reference pulse (MP4130.x)

		Set	Reset
W272	**Operating mode** 1: MANUAL OPERATION 2: ELECTRONIC HANDWHEEL 3: POSITIONING WITH MANUAL DATA INPUT 4: PROGRAM RUN, SINGLE BLOCK 5: PROGRAM RUN, FULL SEQUENCE 7: REFERENCE MARK TRAVERSE	NC	NC
W1032	**Reference marks not yet traversed** Bits 0 to 8 represent axes 1 to 9	NC	NC
W1054	**Reference end position** Bits 0 to 8 represent axes 1 to 9	PLC	PLC

Renewed traversing of the reference marks

Module 9220 Renewed traversing of the reference marks

With this module you start an NC or PLC axis or a servo-controlled spindle for traversing the reference mark. It is possible to repeat the reference mark traverse in an axis that has already been referenced. The module can be called in all operating modes. Software limit switches are not effective. The strobe marker must remain set for the entire duration of the reference-mark traverse.

Axis:

- The sequence of functions (MP1350.x) and the velocity for leaving the reference end position (MP1331.x) are defined by machine parameter.
- The velocity and the direction for traversing the reference marks are either taken from MP1330.x and MP1320.x or they are defined in the module.

☞ **Note**

The direction of traverse should be defined in the module only in exceptional cases. Since the reference end position is not considered in this case, the limits of the traverse range may be violated.

- If an axis is started for reference point traverse although the reference mark has already been traversed, the corresponding bit is set in W1032 and the reference mark is traversed again. The same constraints apply as for traversing the reference mark the first time.
- An axis cannot be started for reference mark traverse until all axes are in position.

Servo-controlled spindles:

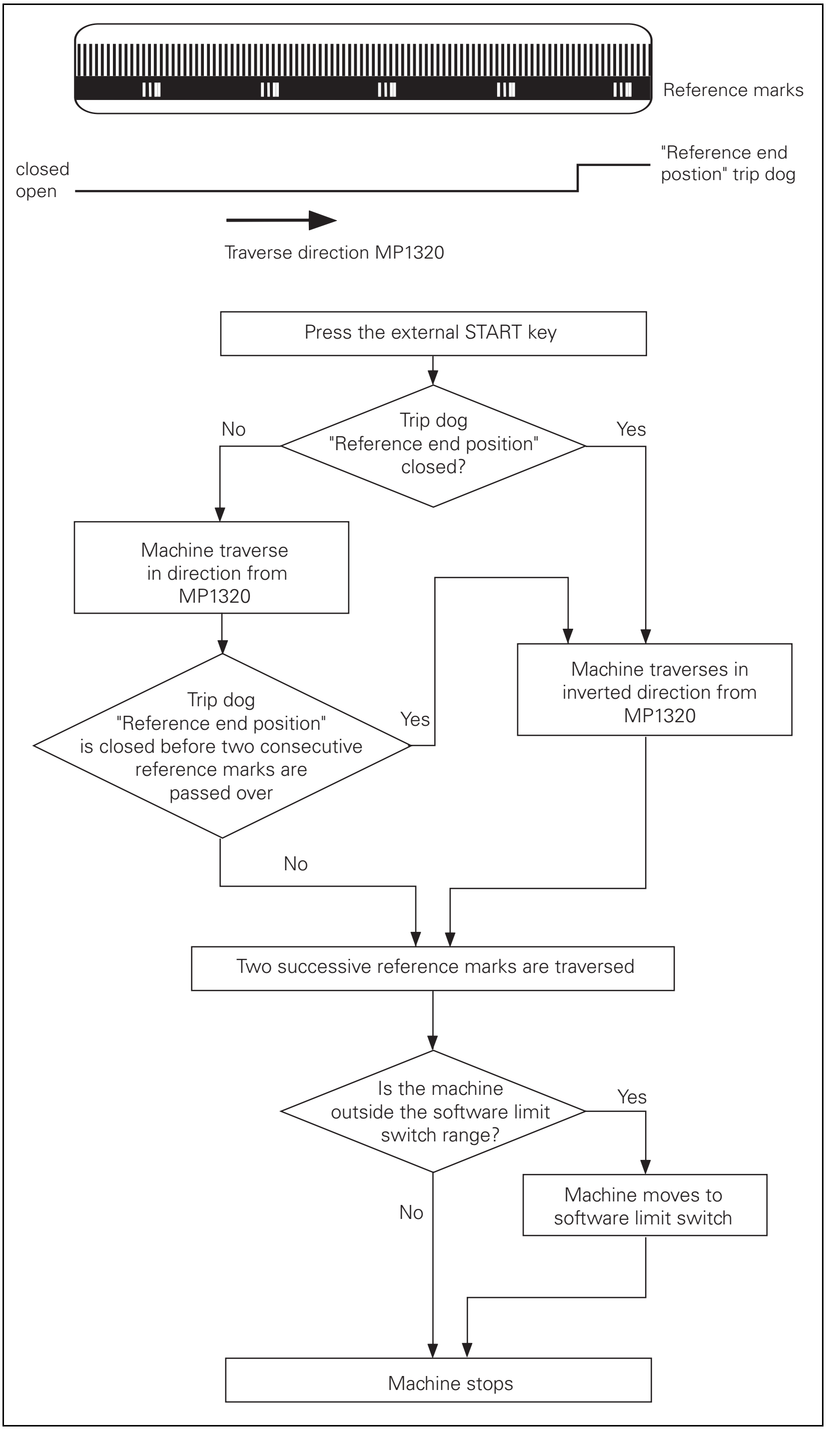
- The speed for traversing the reference mark is defined in the module.
- The spindle must be started from a standstill to traverse the reference mark.
- If the spindle is started for reference mark traverse, marker M4018 is set.

Call:

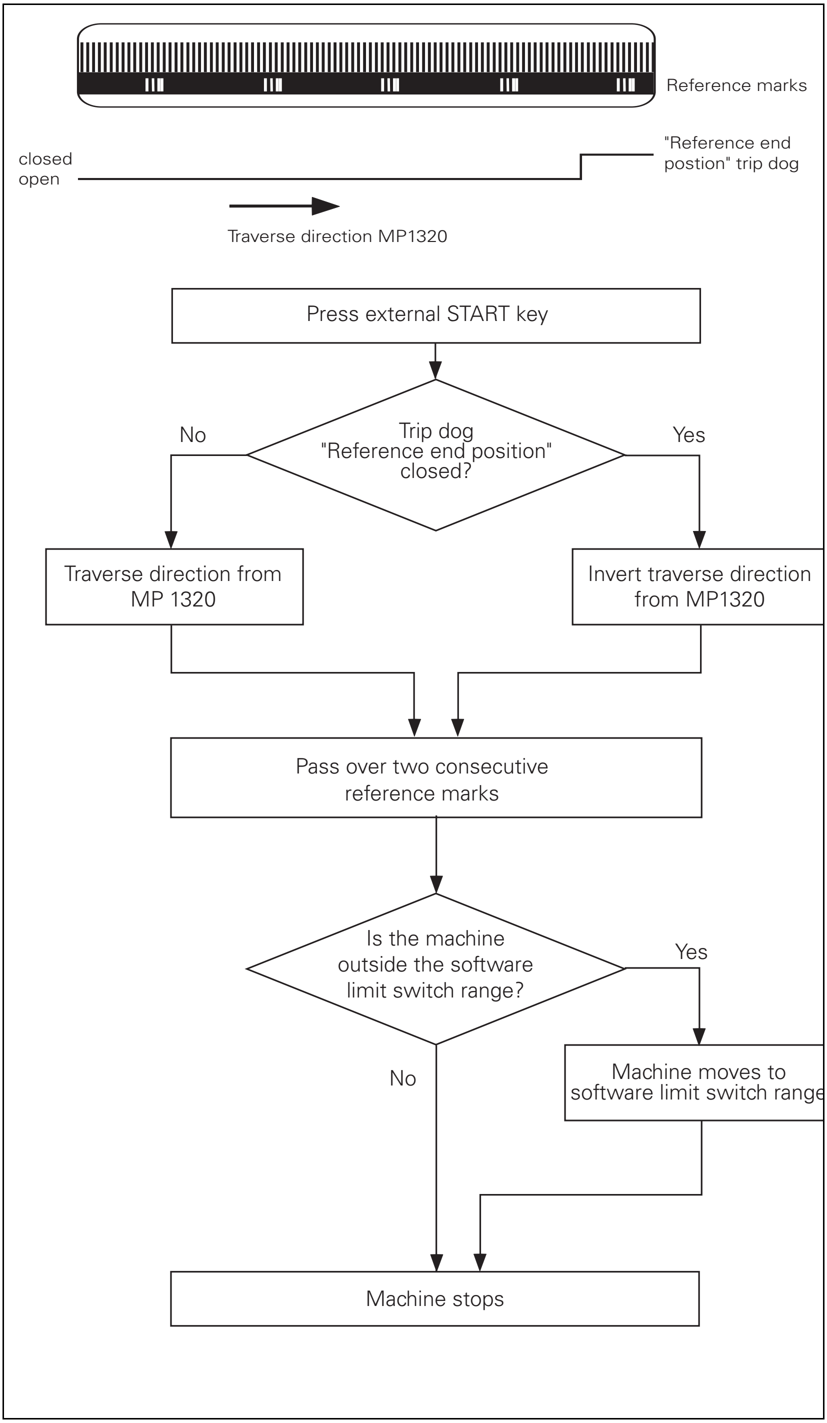
PS	B/W/D/K	<Axis/spindle> 0 to 8: Axes 1 to 9 15: Spindle
PS	B/W/D/K	<Feed rate/shaft speed> 0: Feed rate MP1330.x >0: Feed rate in mm/min or shaft speed in 1/1000 rpm
PS	B/W/D/K	<Direction of traverse> –1: Negative direction 0: Direction from MP1320.x 1: Positive direction
CM	9220	
PL	B/W/D	<Error code> 0: Reference mark traverse is commanded 1: Axis does not exist, or not a servo-controlled spindle 2: Inadmissible values for the feed rate / direction 4: Reference traverse not possible because reference traverse already started 5: Axis is already being positioned or the spindle is in motion 6: Other axis is already being positioned 8: Programmed axis not in closed loop

Position encoder with distance-coded reference marks

Function when MP1350.x = 3



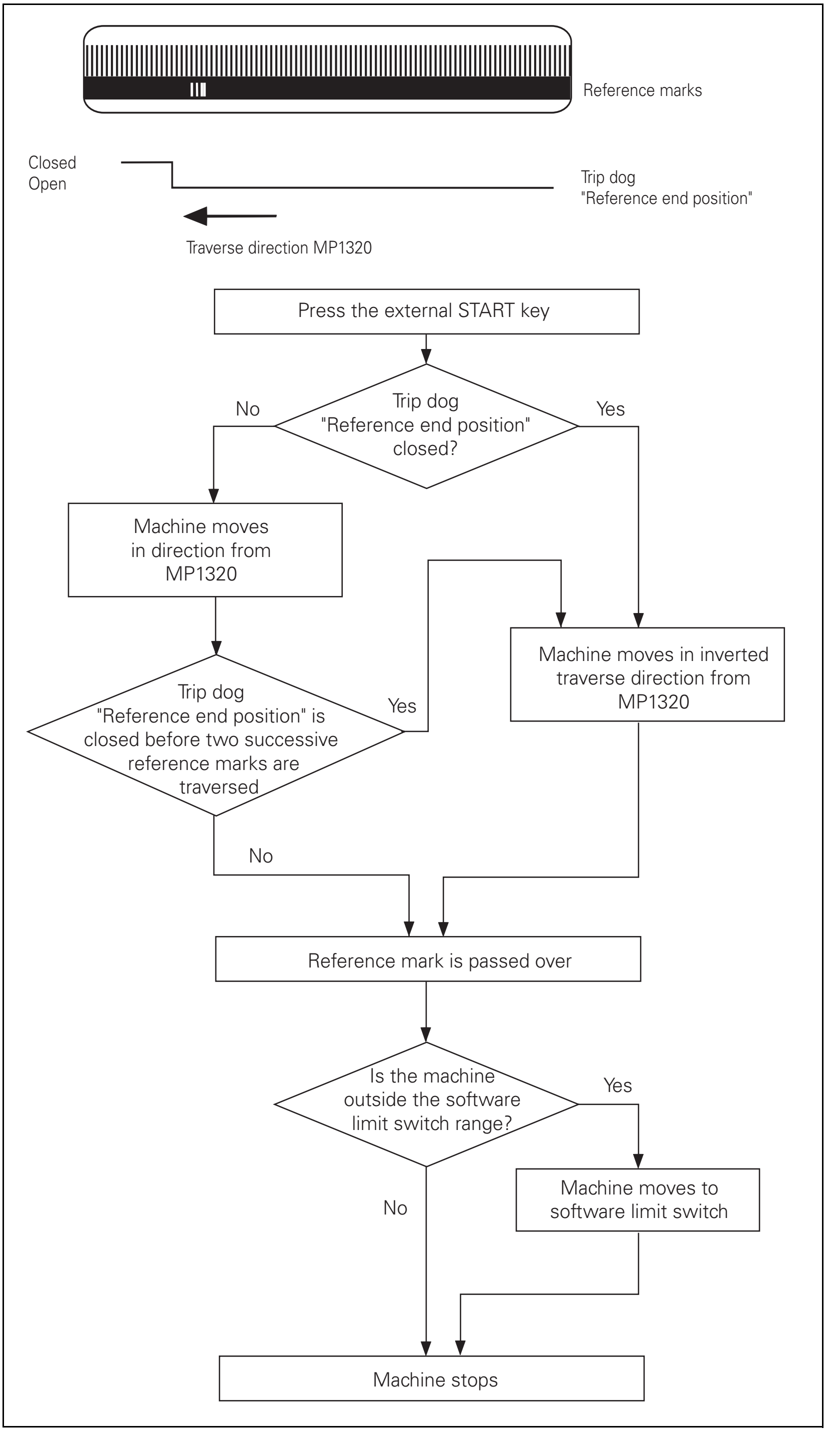
Function when MP1350.x = 0. This setting is used only to ensure compatibility. Do not use for new installations.



If during automatic referencing the trip dog is not closed until it is in the reference end position range, the contouring control will ignore this signal. It is therefore necessary that there be at least two reference marks in the range of the reference end position.

Position encoder with one reference mark

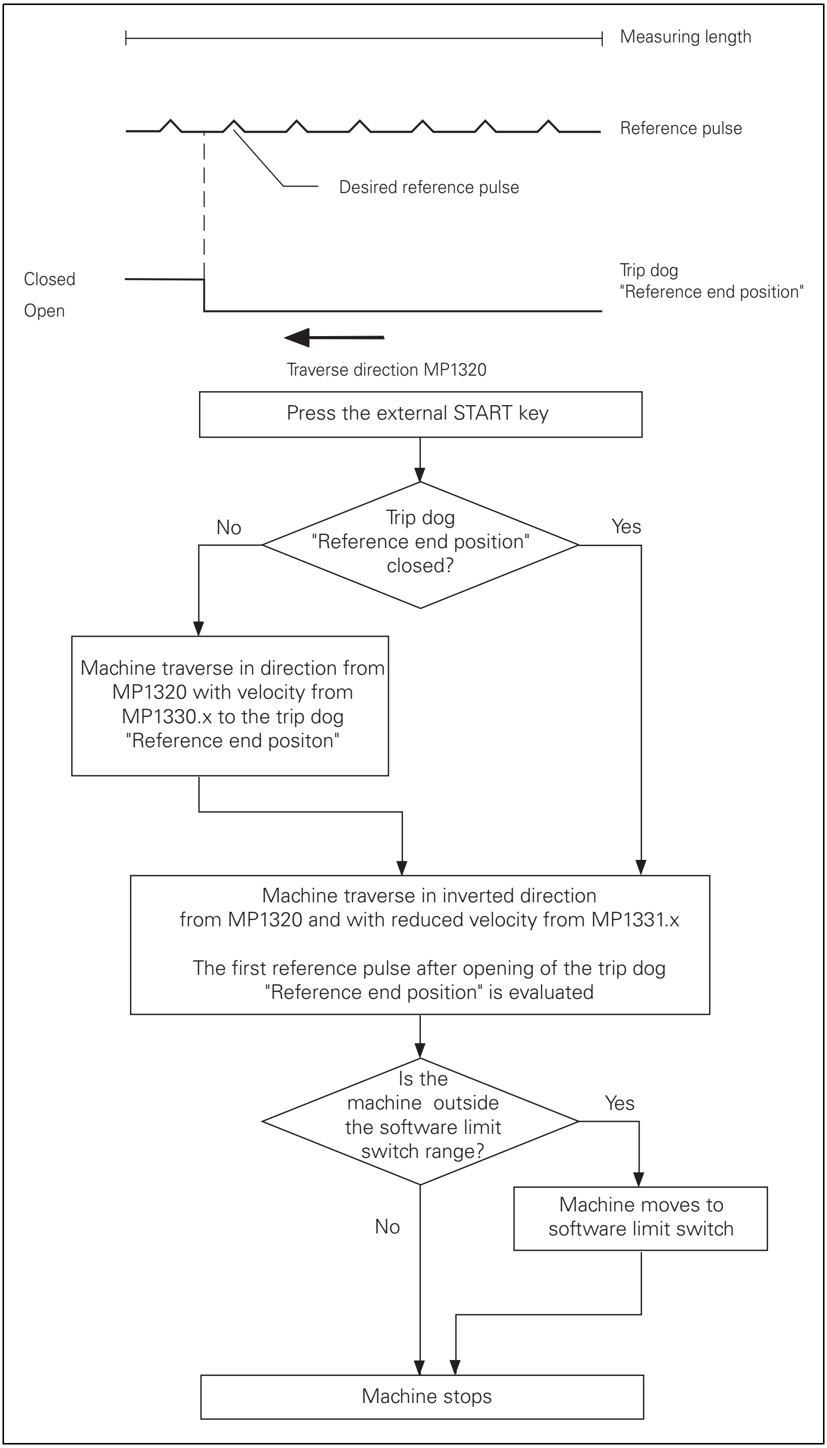
Function when MP1350.x = 1



Linear measurement through rotary encoder

Function when MP1350.x = 2

For linear measurement using a rotary encoder, a reference pulse is produced at each revolution of the encoder. Ensure that during referencing the same reference pulse is always evaluated. This can be realized with the trip dog for reference end position.



6.8 The Control Loop

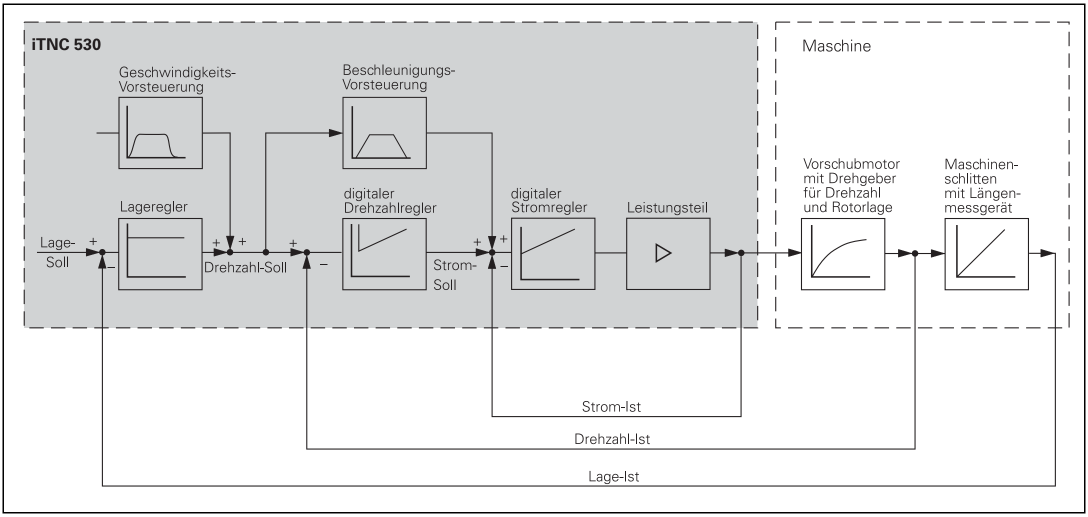
Machine tools normally function on the principle of cascade control. Here the position control loop is prior to the speed and current control loops.

Benefits of cascade control:

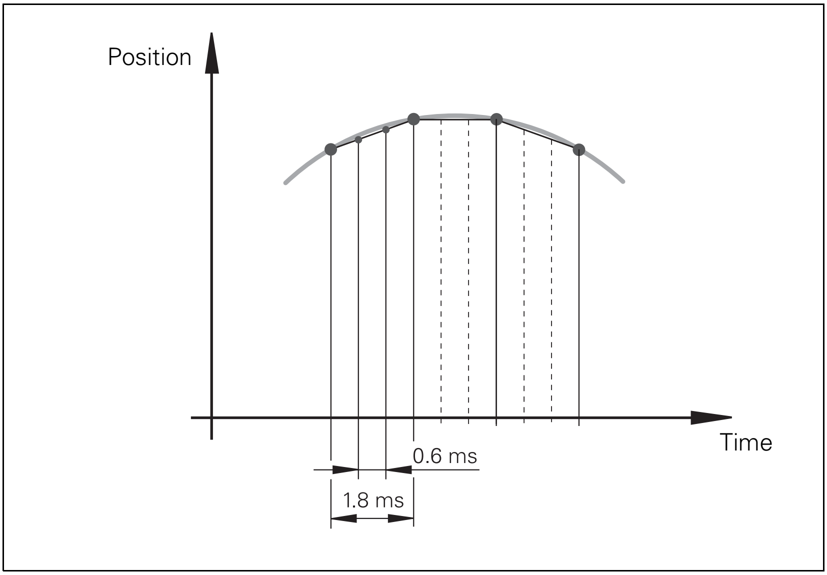
- Transparent structure of the individual control loops.
- Disturbances can be compensated through the subsequent controllers. This relieves the prior controller.
- The respective outer control loop protects the inner control loop by limiting the command variable.
- Individual commissioning of each control loop, starting with the innermost loop.

The position, speed, and current controllers, and the power module are integrated in the iTNC. The power module is driven by the CC 42x through PWM signals (PWM = pulse width modulation).

The iTNC 530 controls machines with up to 11 axes and a spindle or up to 10 axes and 2 spindles. Spindle speeds up to 40 000 rpm for motors with two pole pairs are possible.



The **position controller cycle time** is the time interval during which the interpolation points on the path are calculated. The **speed controller cycle time** is the time interval in which the actual speed value is compared to the calculated nominal speed value. The **current controller cycle time** is the time interval in which the actual current value is compared to the calculated nominal current value.



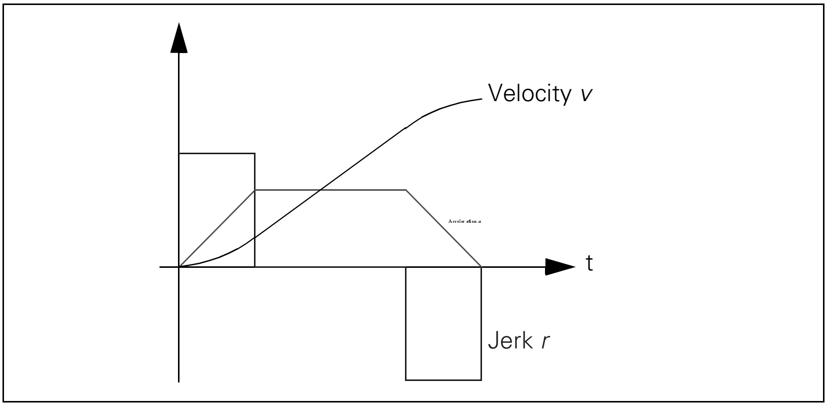
6.8.1 Relation Between Jerk, Acceleration, Velocity and Distance

To ensure proper operation of an axis, the following two conditions must be fulfilled:

- The desired maximum speed v_{max} and maximum jerk r_{max} result in a maximum acceleration a_{max}.
- A minimum distance s_{min} must be traversed in order to attain the maximum speed v_{max}.

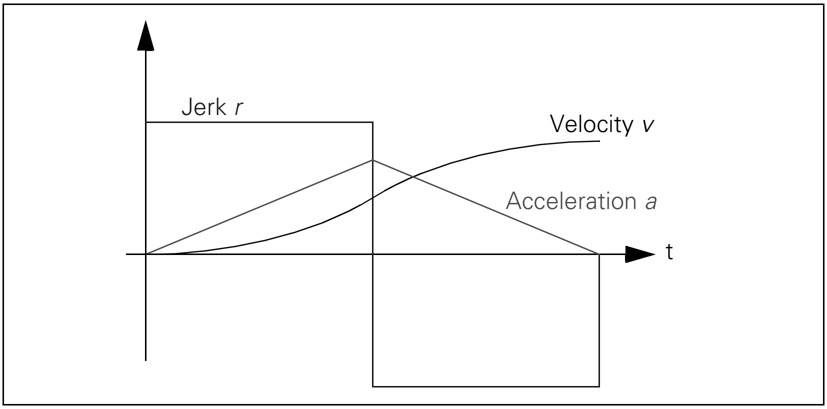
Maximum acceleration

Taking into account the motor and the power module, the machine should be specified in such a way that acceleration during the acceleration phase is as constant as possible. This ensures maximum utilization of the drive current.



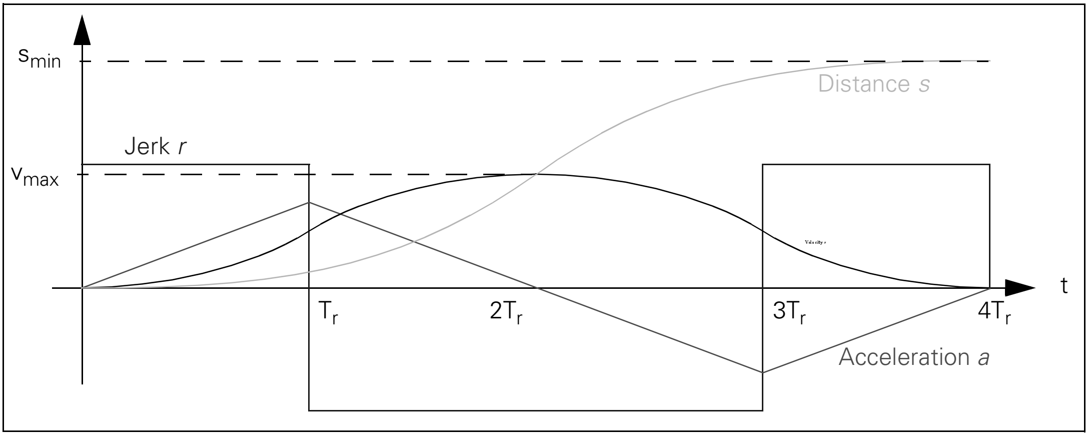
The machine, on the other hand, should be designed to fulfill the following dynamic requirements: The jerk should be kept to a minimum and the jerk phase should be maximized in order to prevent the machine from oscillating. The result is no constant acceleration, but a short acceleration peak. If the maximum velocity and the maximum permissible jerk of the machine are preset, the maximum attainable velocity can be determined.

$$a_{max} = \sqrt{v_{max} \cdot r_{max}}$$



Minimum distance To attain the maximum velocity, a minimum distance s_{min} must be traversed. If the traversed distance is greater than s_{min}, a movement with constant speed is inserted at the time $2T_r$. The minimum distance is:

$$s_{min} = 2 \cdot v_{max} \cdot \sqrt{\frac{v_{max}}{r_{max}}}$$



Example Rapid traverse v_{max} = 30 000 mm/min (= 0.5 m/s); MP1010.x = 30000
Max. jerk with velocity v > 20 000 mm/min (= 0.33 m/s) r_{max1} = 70 m/s^3; MP1090.1 = 70, MP1092 = 20000
Max. jerk r_{max2} = 35 m/s^3 during machining; MP1090.0 = 35

Maximum attainable acceleration a_{max1} during rapid traverse:

$$a_{max1} = \sqrt{v_{max} \cdot r_{max1}} = \sqrt{0{,}5\ \frac{m}{s} \cdot 70\ \frac{m}{s^3}} = 5{,}92\ \frac{m}{s^2}$$

Maximum attainable acceleration a_{max2} during machining (v up to 20 000 mm/min):

$$a_{max2} = \sqrt{v_{max} \cdot r_{max2}} = \sqrt{0{,}33\ \frac{m}{s} \cdot 35\ \frac{m}{s^3}} = 3{,}40\ \frac{m}{s^2}$$

Distance s_{min} required to attain rapid-traverse velocity:

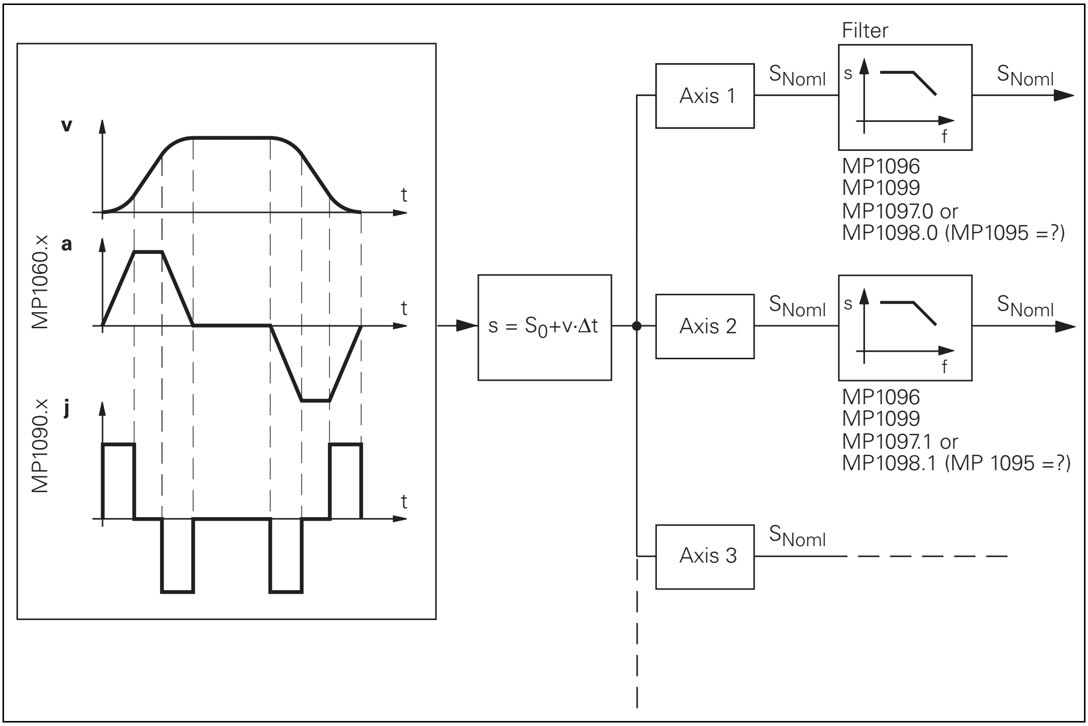
$$s_{min} = 2 \cdot v_{max} \cdot \sqrt{\frac{v_{max}}{r_{max}}} = 2 \cdot 0{,}5\ \frac{m}{s} \cdot \sqrt{\frac{0{,}5\ \frac{m}{s}}{70\ \frac{m}{s^3}}} = 0{,}085\ m = 85\ mm$$

Note

The rectangular jerk curve is rounded through the use of a nominal position value filter (MP1096 ≠ 0). As a result, acceleration is reduced and the minimum distance required for attaining the maximum velocity is increased.

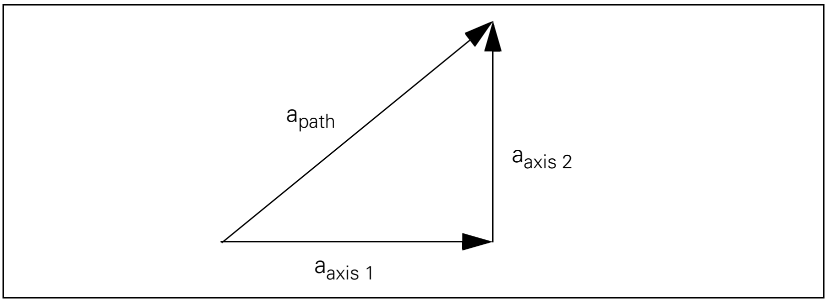
6.8.2 Interpolator

Schematic of the Interpolator:



The interpolator calculates a velocity every 1.8 ms from the programmed feed rate. The value is also dependent on the acceleration curve and the end position.

If more than one axis is moved simultaneously, the path acceleration a_{path} is formed from the appropriate axis components. The same applies to rapid traverse in the path (See "Rapid traverse" on page 6 – 134).



If the inverter is not designed for such accelerations, you can limit the path acceleration:

▶ In MP1061, enter the maximum permissible path acceleration.

You must adjust the velocity feedforward value to the dynamics of the machine:

- With MP1060.x you define the acceleration or the steepness of the velocity curve.
- In MP1090.x, you limit the jerk for the **Program run full sequence** and **Program run single block** modes of operation. The jerk is the rate of change in acceleration. The greater the entered value, the more the system will tend to oscillate.
- In MP1086.x, you limit the jerk for single-axis motions at rapid traverse in the **Program run full sequence, Program run single block** and **Positioning with manual data input** modes of operation.
- Use MP1087.x to limit the axis-specific jerk in **Manual mode.**
- Use MP1089.x to limit the axis-specific jerk in the **Pass Over Reference Point** mode of operation. This is necessary if you want to brake or accelerate faster in this operating mode than in other operating modes.

Please note:

$$\text{Jerk} = \frac{a^2}{v}$$

At high feed rates (e.g. rapid traverse) a higher jerk is permitted than at low feed rates:

- Enter the jerk for low feed rates in MP1090.0, and for high feed rates in MP1090.1. MP1090.x is the jerk on the tool path. The input value is determined by the weakest axis.
- In MP1092, define a machining feed rate beginning at which MP1090.1 becomes effective.

A nominal position value is acquired every 1.8 ms from the calculated velocity. For linear interpolation:

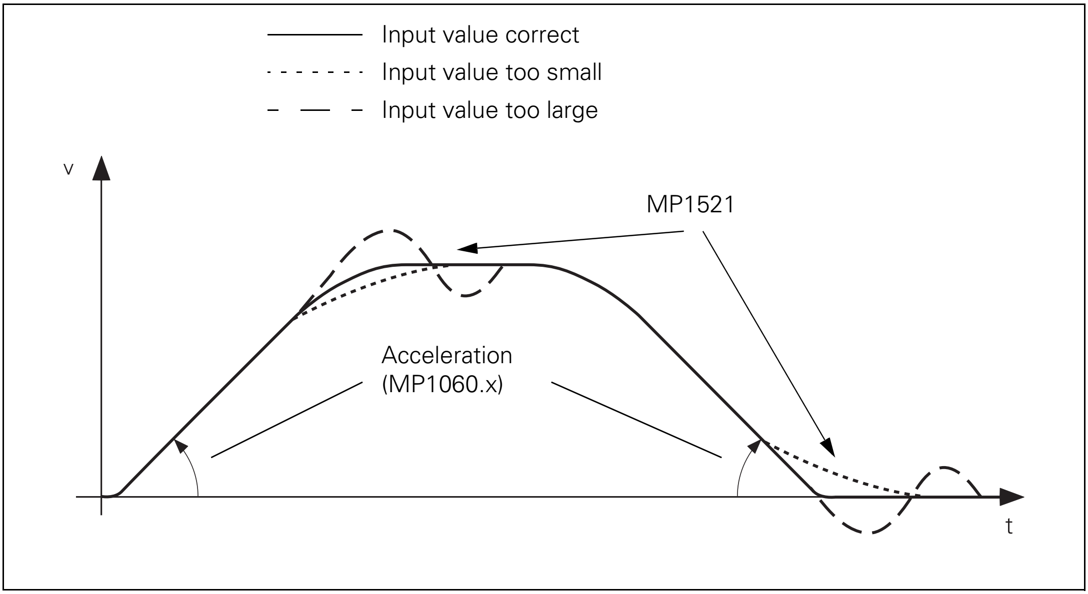
$$s = s_O + v \cdot \Delta t$$

s = nominal position value
s_o = previous nominal position value
v = calculated velocity
Δt = cycle time

The nominal position value is resolved into the individual axis components, depending on which axes have been programmed.

It may happen that the axes at first move past the target position and then oscillate onto it. This overshoot behavior during acceleration and braking can be influenced by a time constant:

▶ In MP1521, define the time constant for the overshoot behavior.



Nominal position value filter

To attain a high machining velocity, the workpiece contour can be adapted to the machine dynamics by means of a nominal position value filter. Here the iTNC always complies with the tolerance (MP1096, Cycle 32), the axis-specific jerk (MP1097.x, MP1098.x), the acceleration (MP1060.x) and the radial acceleration (MP1070.x).

The iTNC calculates the filter parameters automatically. For test purposes, you can deactivate some of the parameters in MP7684 bits 0 to 4 for the calculation.

- Enter the permissible axis-specific jerk:
  - For single filter: MP1097.x (at corners)
  - For double filter: MP1098.x (at corners)
  - For HSC filter: MP1098.x (at corners), MP1097.x (at curvature changes, e.g. tangential transition from a line to an arc)
- In MP1096, define a tolerance for contour transitions. This tolerance can be overwritten by the machine user with Cycle 32 “Tolerance.”
- Select from the following tables the input values for MP1099.x or MP1094. Note the lowest resonance frequency of your machine axes and the desired damping at this frequency.

Note

The tolerance (MP1096, Cycle 32) always refers to the nominal value, meaning the servo lag also affects the contour accuracy.
For example, if the servo lag S = 5 µm and the tolerance T = 10 µm, then the total deviation is 15 µm.

Note

In order to achieve the same behavior with the single and double filters as with the TNC 426/TNC 430, you must convert the values for the minimal filter order (MP1099.x):

$$FO_{iTNC\ 530} = \frac{(FO_{TNC\ 426/TNC\ 430} + 1) \cdot t_{TNC\ 426/TNC\ 430}}{t_{iTNC\ 530}} - 1$$

$FO_{TNC\ 426/TNC\ 430}$: Minimal filter order TNC 426/TNC 430 (MP1099.x)
$FO_{iTNC\ 530}$: Minimal filter order iTNC 530 (MP1099.x)
$t_{TNC\ 426/TNC\ 430}$: Position controller cycle time TNC 426/TNC 430
$t_{iTNC\ 530}$: Position controller cycle time iTNC 530

Single filter (MP1099.0)
with 1.8 ms position controller cycle time

Damping [dB]	Frequency to be damped [Hz]										
	5	**7.5**	**10**	**12.5**	**15**	**20**	**25**	**30**	**35**	**40**	**50**	**60**
3	–	–	17	14	11	8	6	5	5	4	3	3
6	–	–	–	19	16	12	9	7	6	5	4	4
9	–	–	–	–	19	14	11	9	8	7	5	4
12	–	–	–	–	–	16	13	10	9	8	6	5
15	–	–	–	–	–	18	14	11	10	8	7	6

Single filter (MP1099.0)
with 3 ms position controller cycle time

Damping [dB]	Frequency to be damped [Hz]										
	5	**7.5**	**10**	**12.5**	**15**	**20**	**25**	**30**	**35**	**40**	**50**	**60**
3	21	14	10	8	7	5	4	3	3	2	2	1
6	–	19	14	11	9	7	5	4	4	3	3	2
9	–	–	17	14	11	8	7	5	5	4	3	3
12	–	–	19	15	13	10	8	6	5	5	4	3
15	–	–	–	17	14	10	8	7	6	5	4	3

Double filter (MP1099.1)
with 1.8 ms position controller cycle time

Damping [dB]	Frequency to be damped [Hz]										
	5	**7.5**	**10**	**12.5**	**15**	**20**	**25**	**30**	**35**	**40**	**50**	**60**
3	–	16	12	9	8	6	5	4	3	3	2	2
6	–	–	17	13	11	8	7	5	5	4	3	3
9	–	–	21	16	14	10	8	7	6	5	4	3
12	–	–	–	19	16	12	9	8	7	6	4	4
15	–	–	–	21	18	13	10	9	7	6	5	4

Double filter (MP1099.1)
with 3 ms position controller cycle time

Damping [dB]	Frequency to be damped [Hz]										
	5	**7.5**	**10**	**12.5**	**15**	**20**	**25**	**30**	**35**	**40**	**50**	**60**
3	14	10	7	6	5	3	3	2	2	2	1	1
6	21	13	10	8	7	5	4	3	3	2	2	1
9	–	16	12	10	8	6	5	4	3	3	2	2
12	–	19	14	11	9	7	5	4	4	3	3	2
15	–	21	16	12	10	8	6	5	4	4	3	2

HSC filter (MP1094)
with 1.8 ms position controller cycle time

Damping [dB]		Frequency to be damped [Hz]									
	10	**12.5**	**15**	**17.5**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**60**
3	11	12	15	18	24	28	36	41	46	51	56	66
6	–	11	12	14	18	25	29	35	40	45	50	60
9	–	–	11	12	16	22	27	32	36	41	46	56
12	–	–	–	11	14	20	24	27	30	38	42	52
15	–	–	–	–	12	19	23	25	28	35	40	50

HSC filter (MP1094)
with 3 ms position controller cycle time

Damping [dB]		Frequency to be damped [Hz]										
	10	**12.5**	**15**	**17.5**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**60**
3	10	15	18	21	23	28	33	38	43	48	53	62
6	8	11	15	17.5	20	25	30	35	40	45	50	60
9	–	10	13	16	17	22	27	32	37	42	47	57
12	–	9	12	14	16	20	25	30	35	40	45	50
15	–	8	11	13	15	19	24	29	34	39	44	49

▶ With MP1095.x you select the single or double filter. The HSC filter is switched on with MP1094.
MP1095.1 is effective in the Manual, Handwheel, Incremental Jog Positioning and Reference Mark Traverse modes. MP1095.0 and MP1094 are effective in the Program Run Single Block, Program Run Full Sequence and MDI modes. If MP1094 is used, MP1095.0 is without effect.
Example:
Set the double filter in the Program Run modes for a smooth traverse (MP1095.0 = 1), or set the single filter in the Manual mode for a shorter deceleration path (MP1095.1 = 0).

▶ Test the three filter settings using a test part made of short line segments.
- Single filter
- Double filter
- HSC filter

Note

If you have selected the best nominal position value filter for your application, please note that your input value can be overwritten by the machine user through Cycle 32. If you have switched off the nominal position value filter (MP1096 = 0), the machine user can also switch it on using Cycle 32.

The nominal position value filters function in all operating modes (even in rapid traverse). For RIGID TAPPING (Cycle 17), the nominal position value filter is automatically switched off.

Machine parameters	Single filter	Double filter	HSC filter
HSC filter MP1094	MP1094 = 0	MP1094 = 0	MP1094 = Cutoff frequency
Single/double filter MP1095.x	MP1095.x = 0	MP1095.x = 1	MP1095.0 = Nonfunctional MP1095.1 = 0 or 1
Tolerance for contour transitions MP1096	MP1096 = Tolerance (Cycle 32)		
Axis-specific jerk for single filter MP1097.x	MP1097.x = Jerk (at corners)	MP1097.x = Nonfunctional	MP1097.x = Jerk (at curvature changes)
Axis-specific jerk for double filter MP1098.x	MP1098.x = Nonfunctional	MP1098.x = Jerk (at corners)	MP1098.x = Jerk (at corners)
Minimum filter configuration MP1099.x	MP1099.0 = Filter order	MP1099.1 = Filter order	MP1099.x = Nonfunctional

MP1060.x **Acceleration**
Input: 0.001 to 100.000 [m/s^2 or 1000°/s^2]

MP1061 **Limitation of the path acceleration**
Input: 0.001 to 100.000 [m/s^2 or 1000°/s^2]

MP1086.x **Maximum permissible jerk during single-axis movements at rapid traverse for the operating modes Program Run Full Sequence, Program Run Single Block, and Positioning with Manual Data Input**
Input: 0: Function inactive
0.1 to 1000.0 [m/s^3 or 1000°/s^3]

MP1087.x **Maximum permissible axis-specific jerk for Manual mode**
Input: 0.1 to 1000.0 [m/s^3 or 1000°/s^3]

MP1089.x **Maximum permissible axis-specific jerk for Pass Over Reference Point mode**
Input: 0.1 to 1000.0 [m/s^3 or 1000°/s^3]

MP1090 **Maximum permissible jerk on the tool path**
Input: 0.1 to 1000.0 [m/s^3 or 1000°/s^3]
MP1090.0 With machining feed rate
MP1090.1 Beginning with feed rate from MP1092

MP1092 **Feed rate threshold from which MP1090.1 becomes effective**
Input: 10 to 300 000 [mm/min]

MP1094 **HSC filter**
Input: 0: HSC filter inactive
0.1 to 166.0: Cutoff frequency for HSC filter

MP1095 **Nominal position value filter**
Input: 0: Single filter
1: Double filter
MP1095.0 In the Program Run Full Sequence, Program Run Single Block, and Positioning With Manual Data Input operating modes
MP1095.1 In the Manual, Handwheel, Jog Increment and Pass Over Reference Point operating modes

MP1096 **Tolerance for contour transitions**

Input: 0: No nominal position value filter
0.001 to 3.000 [mm]: Permissible tolerance at contour transitions

MP1097.x **Maximum permissible axis-specific jerk (single/HSC filter)**

Input: 0.1 to 1000.0 [m/s^3 or 1000°/s^3]

MP1098.x **Maximum permissible axis-specific jerk (double/HSC filter)**

Input: 0.1 to 1000.0 [m/s^3 or 1000°/s^3]

MP1099 **Minimum filter order**

Input: 0 to 20
MP1099.0 Minimum filter configuration for single filter (MP1095 = 0)
MP1099.1 Minimum filter configuration for double filter (MP1095 = 1)

MP1521 **Transient response during acceleration and deceleration**

Input: 1 to 255 [ms]
0: Function inactive

MP7684 **Nominal position value filter and path control with M128**

Format: %xxxxxxxx
Input: Bit 0 - Nominal position value filter
0: Include acceleration
1: Do not include the acceleration
Bit 1 – Nominal position value filter
0: Include the jerk
1: Do not include the jerk
Bit 2 – Nominal position value filter
0: Include the tolerance
1: Do not include the tolerance
Bit 3 – Nominal position value filter
0: Include the radial acceleration
1: Do not include the radial acceleration
Bit 4 – Nominal position value filter
0: Include curvature changes
1: Do not include curvature changes

Feed-rate smoothing

Fluctuations in feed rate sometimes occur during execution of NC programs consisting of short straight-line segments. MP7620 bit 6 smoothes the feed rate. However, it also reduces it somewhat.

MP7620	**Feed-rate override and spindle speed override**
Input:	Bit 6 – Feed-rate smoothing 0: Not active 1: Active

Tolerance consideration with M128

During program run with M128 the head dimensions are also included in the tolerance consideration (MP1096, Cycle 32). This means that the control tries to observe the tolerance, taking the head dimensions into account. As a result, the tolerance is reduced, which leads to a reduction of the feed rate and might cause the rotary axis to jerk.

To switch off the consideration of the head dimensions for rotary axes with M128:

▶ Enter bit 4 = 1 in MP7682.

MP7682	**Machine parameter with multiple function**
Input:	Bit 4 – Tolerance of rotary axes with M128 0: With consideration of head dimensions 1: Without consideration of head dimensions

6.8.3 Position Controller

Position controller cycle time

With MP7600.0 you can set the position controller cycle time.

- In MP7600.0, enter a factor which, when multiplied by 0.6 ms, results in the position controller cycle time.

With the input value MP7600.0 = 3, the iTNC has a minimum position controller cycle time of 1.8 ms. The increase of the position controller cycle time also increases the PLC cycle time. To return to the previous PLC cycle time, enter the corresponding factor in MP7600.1. For entries which lead to a PLC cycle time < 10 ms, the PLC cycle time is limited to 10 ms.

MP7600.0	**Position controller cycle time = MP7600.0 · 0.6 ms**
Input:	1 to 20 Proposed input value: 3 (= 1.8 ms)

MP7600.1	**PLC cycle time = position controller cycle time · MP7600.1**
Input:	1 to 20 Proposed input value: 6 (= 10.8 ms)

You can choose between two types of feedback control:

- Feedback control with following error (servo lag)
- Feedback control with velocity feedforward
- Select the type of control in the **`Positioning with manual data input, Program run, single block`** and **`Program run, full sequence`** operating modes with MP1392.
- Select the type of control in the **`Manual`** and **`Handwheel`** modes of operation with MP1391.

Note

The machine must always be adjusted for both types of control.

MP1392	**Velocity feedforward in the POSITIONING WITH MANUAL DATA INPUT, PROGRAM RUN SINGLE BLOCK and PROGRAM RUN FULL SEQUENCE operating modes**
Format:	%xxxxxxxxxxxxxx
Input:	Bits 0 to 13 represent axes 1 to 14 0: Operation with following error (lag) 1: Operation with velocity feedforward control

Note

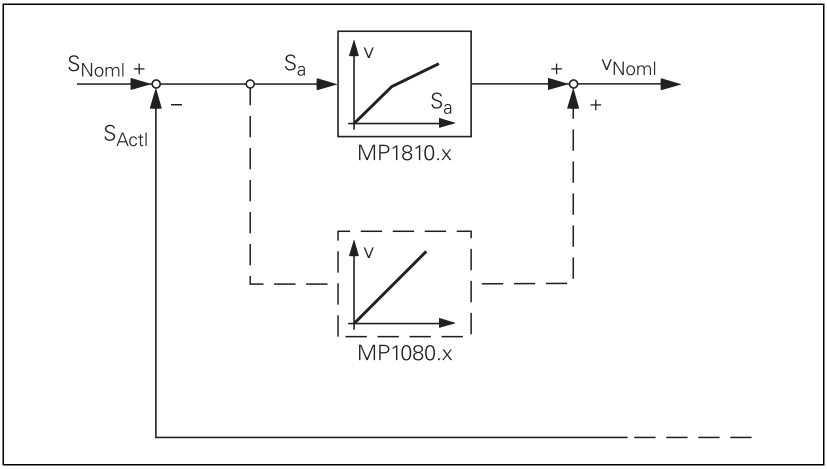
M90 (lag mode: Constant contouring speed at corners) is effective only if operation with following error is selected for all axes (MP1392 = %00000000000000).

MP1391	**Velocity feedforward control in the MANUAL and HANDWHEEL operating modes**
Format:	%xxxxxxxxxxxxxx
Input:	Bits 0 to 13 represent axes 1 to 14 0: Operation with following error (lag) 1: Operation with velocity feedforward control

Feedback control with following error

Following error (also known as servo lag) is a gap that remains between the nominal position commanded by the NC and the actual position.

Simplified representation:



The nominal position value s_{noml} for a given axis is compared with the actual position value s_{actl} and the resulting difference is the following error s_a:

$s_a = s_{Noml} - s_{Actl}$

s_a = following error
s_{Noml} = nominal position value
s_{Actl} = actual position value

The following error is multiplied by the k_v factor and passed on as nominal velocity value:

$v_{noml} = k_v \cdot s_a$

v_{noml} = nominal velocity value

Analog axes:
For stationary axes, the integral factor has an additional effect (MP1080.x). It produces an offset adjustment.

Digital axes:
There is no offset. MP1080.x has no function.

k_v factor during control with following error

The control loop gain, known as the k_v factor, defines the amplification of the position control loop. You must find the optimum k_v factor by trial and error.

If you choose a k_v factor that is too large, the following error will become very small. However, this can lead to oscillations.

If you choose too small a k_v factor, the axis will move to a new position too slowly.

For axes that are interpolated with each other, the k_v factors must be equal to prevent contour deviations.

- In MP1810.x define a set of k_v factors for operation with following error.

You can selectively increase the contour accuracy with a higher k_v factor . This k_v factor is activated with the M function M105:

- In MP1815.x define a second set of k_v factors and activate them with M105.

M105 also influences compensation of reversal spikes during circular motion. With M106 you can switch back to the original set of k_v factors:

- Enable the M functions M105/M106 with MP7440, bit 3.

Interrelation of k_v factor, feed rate, and following error

The following formula shows the interrelation of k_v factor, feed rate, and following error:

$$k_v = \frac{v_e}{s_a} \quad \text{Or} \quad s_a = \frac{v_e}{k_v}$$

k_v = loop gain [(m/min)/mm]
v_e = rapid traverse [m/min]
s_a = following error [mm]

MP1810.x	**k_v factor for control with following error**
Input:	0.100 to 20.000 [(m/min)/mm]
MP1815.x	**k_v factor for control with following error effective after M105**
Input:	0.100 to 20.000 [(m/min)/mm]
MP7440	**Output of M functions**
Format:	%xxxxx
Input:	Bit 3 – Switching the k_v factors with M105/M106 0: Function is not in effect 1: Function is effective

Feedback control with velocity feedforward

The nominal velocity value consists of an open-loop and a closed-loop component.

With velocity feedforward control, the machine-adjusted nominal velocity value is the open-loop controlled component. The closed-loop velocity component is calculated through the following error. The following error is small.

In most cases, machines are controlled with velocity feedforward, since it makes it possible to machine exact contours even at high speeds.

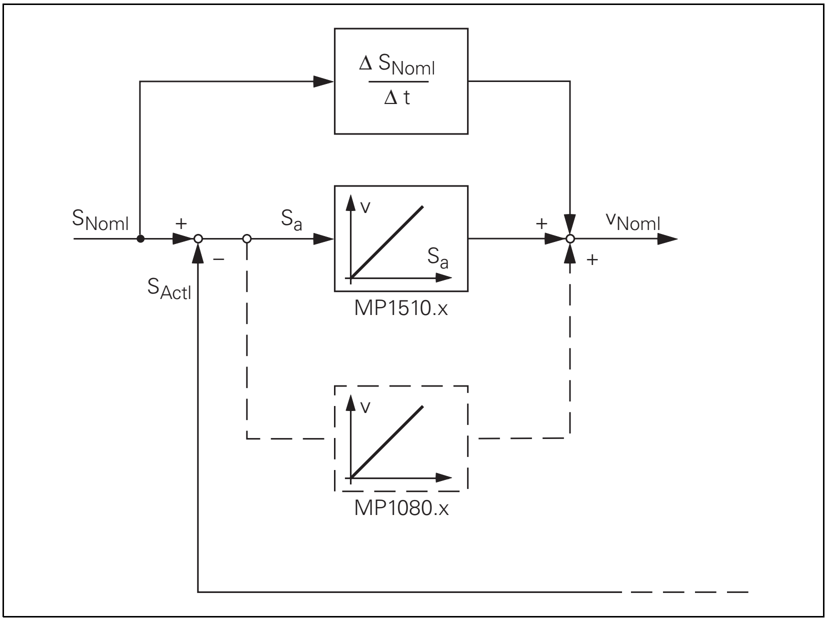
For the **Positioning with manual data input, Program run, single block** and **Program run, full sequence** operating modes:

▶ Switch on the velocity feedforward control with MP1392.

For the MANUAL and HANDWHEEL operating modes:

▶ Switch on the velocity feedforward control with MP1391.

Block diagram:

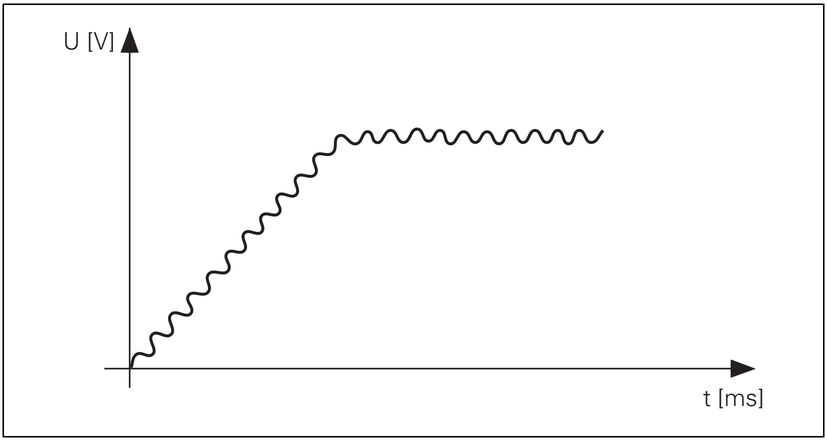


Analog axes:
For stationary axes, the integral factor has an additional effect (MP1080.x). It produces an offset adjustment.

Digital axes:
There is no offset. MP1080.x has no function.

You can influence the control of the forward-fed velocity with the k_v factor:

▶ In MP1510.x, enter a k_v factor.



Warning

If the k_V factor that you select is too large, the system will oscillate around the forward-fed nominal velocity value.

Unlike operation with following error, you must also enter the optimum k_V factor for each axis when operating with interpolated axes.

You can selectively increase the contour accuracy with a higher k_V factor. This k_V factor is activated with M105:

- In MP1515.x, define a second set of k_V factors and activate them with M105.

M105 also influences compensation of reversal spikes during circular motion. With M106 you can switch back to the original set of k_V factors:

- Enable the M functions M105/M106 with MP7440, bit 3.

MP1510.x **k_V factor for velocity feedforward control**
Input: 0.100 to 1000.000 [(m/min)/mm]

MP1515.x **k_V factor for velocity feedforward control effective after M105**
Input: 0.100 to 20.000 [(m/min)/mm]

MP7440 **Output of M functions**
Format: %xxxxx
Input: Bit 3 – Switching the k_V factors with M105/M106:
0: Function is not in effect
1: Function is effective

Feedback control with velocity semifeedforward

MP1396.x allows the operator to switch to velocity semifeedforward control. Normally, work will be carried out using velocity feedforward. Velocity semifeedforward is activated, for example, by an OEM cycle before roughing, in order to permit a higher following error and thereby a higher velocity, combined with a lowered accuracy, in order to traverse corners.
Before finishing, another OEM cycle can be used to switch back to velocity feedforward, in order to finish with the highest accuracy possible.

In order to use velocity semifeedforward, a factor must be entered for every axis in MP1396.x, where values toward 0 control the following error more, and values toward 1 control the velocity feedforward more. The factor can be overwritten with FN17: SYSWRITE ID600. However, the factor from MP1396.x becomes valid again at the end of a program (MP7300 = 1) and whenever a new NC program is selected.

As soon as a factor between 0.001 and 0.999 has been entered in MP1396.x, the k_V factor from MP1516.x becomes effective.

Note

For axes that are interpolated with each other, the k_V factors must be equal. In this case the smaller k_V factor determines the input value for these axes.

The values for position monitoring are interpolated according to the factor in MP1396.x between the values for servo lag (MP1710.x, MP1720.x) and the values for velocity feedforward control (MP1410.x, MP1420.x).

Feedback control with following error (servo lag)	Feedback control with velocity semifeedforward	Feedback control with velocity feedforward
MP1391 bit x = 0 MP1392 bit x = 0 MP1396.x = nonfunctional	MP1391 bit x = 1 MP1392 bit x = 1 MP1396.x = 0.001 ◄──► MP1396.x = 0.999	MP1391 bit x = 1 MP1392 bit x = 1 MP1396.x = 1

To use feedback control with velocity semifeedforward:

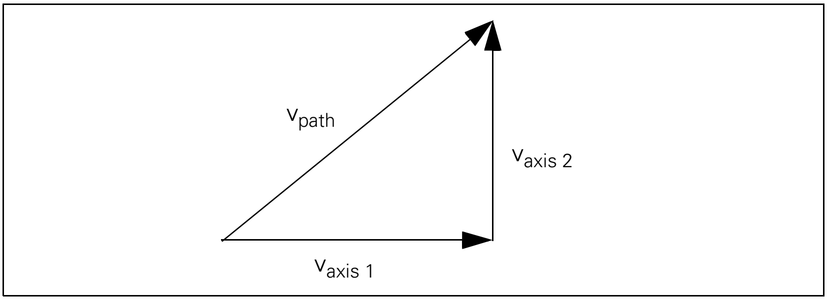
- Activate the velocity feedforward control with MP1391 and/or MP1392.
- Determine the k_V factor for velocity feedforward control (MP1510.x).
- Activate the velocity semifeedforward control by entering the desired factor in MP1396.x.
- Determine the k_V factor for velocity semifeedforward control (MP1516.x).
- Enter MP1396.x = 1 to return to velocity feedforward control.
- For example, you may now use FN17: SYSWRITE ID 600 in an OEM cycle to overwrite or reestablish the factor in MP1396.x.

MP1396.x **Feedback control with velocity semifeedforward**
Input: 0.001 to 0.999
1: Velocity feedforward control

MP1516.x **k_V Factor for velocity semifeedforward**
Input: 0.100 to 20.000 [(m/min)/mm]

Rapid traverse

If more than one axis is moved simultaneously, the rapid traverse on the path v_{path} is formed from the appropriate axis components. The same also applies to the path acceleration (See "Interpolator" on page 6 – 117).



If there are problems with the inverter, e.g. because the energy being generated from the axes in motion cannot be dissipated, you can limit the rapid traverse on the path:

- Enter the maximum rapid traverse on the path in MP1011.
- Enter the inputs axis-specifically in MP1010.x.

You can reduce the rapid traverse on the path through the PLC:

- Enter the reduced value in D596.
  If the value in D596 is larger than MP1011, then MP1011 becomes effective.

After the control is switched on, or after an interruption of the PLC run, D596 is preassigned with the value 300 000 so that MP1011 becomes effective.

Rapid traverse can be limited by the user with the F MAX soft key. This limitation is not effective if M4587 is set. In this case only limitation through D596 is effective. After M4587 is reset, both D596 and the last limit set via the F MAX soft key are effective again.

The feed rate is significantly lower for manual operation than for rapid traverse:

- Enter in MP1020 a feed rate for manual operation.

The programmed feed rate and the current path feed rate are saved in D360 and D388 in mm/min. In the manual operating modes, the highest axis feed of all axes is stored in D388.

The maximum possible feed rate depends on the encoder being used.

v_{max} [mm/min] = P [mm] · f_i [kHz] · 60

v_{max} = Maximum traverse speed
P = Signal period of the encoder
f_i = Input frequency of the encoder input. See "Encoder signals" on page 6 – 8 and See "Encoder Connections" on page 3 – 28.

Digital axes:

For digital axes, the maximum feed rate also depends on the number of pole pairs in the drive motor and the pitch of the ballscrew.

$$v_{max}\ [mm/min] = \frac{30\,000}{\text{No. of pole pairs}}\ [1/min] \cdot \text{ballscrew pitch [mm]}$$

Analog axes:

- In MP1050.x, enter the desired analog voltage for rapid traverse.
- Adjust the rapid traverse feed rate (v_{max}) with the analog voltage at the servo amplifier.

MP1010.x **Rapid traverse**
Input: 10 to 300 000 [mm/min or °/min]

MP1011 **Limit of rapid traverse on the path**
Input: 10 to 300 000 [mm/min or °/min]

MP1020.x **Manual feed**
Input: 10 to 300 000 [mm/min]

MP1050.x **Analog axes: Analog voltage at rapid traverse**
Input: 1 000 to 9 000 [V]
Digital axes: without function
Input: 1

		Set	Reset
M4587	**Feed rate limit exceeded F MAX**	PLC	PLC
D596	**Max. feed rate from PLC [mm/min]**	NC/PLC	PLC
D360	**Programmed feed rate**	NC	NC
D388	**Current tool feed rate [mm/min]**	NC	NC

Position loop resolution

The encoder signals are interpolated 1024-fold.

$$\text{Position loop resolution [µm]} = \frac{\text{Signal period [µm]}}{1024}$$

Analog axes

The iTNC outputs a voltage per position error. The 10-V analog voltage is subdivided 65536-fold with a 16-bit D/A converter. This results in a smallest voltage step of 0.15 mV.

Rapid traverse (MP1010.x) is attained at a certain voltage (MP1050.x). This results in the voltage ΔU per position error or following error s_a:

$$\Delta U = \frac{\text{MP1050.x [mV]}}{S_a\,[\text{µm}]}$$

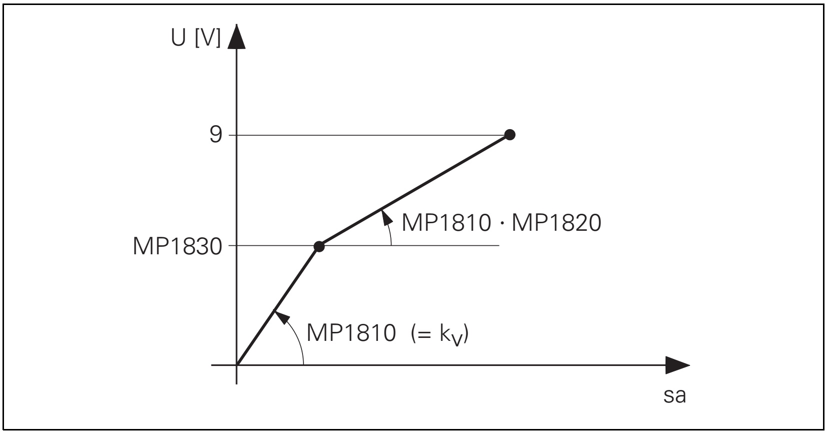
If ΔU is divided by the smallest possible voltage step (0.15 mV), the result is the number *n* of the possible voltage steps per position error.

Characteristic curve kink point (for control with following error)

For machines with high rapid traverse, you can not increase the k_V factor enough for an optimum control response to result over the entire velocity range (from standstill to rapid traverse).

In this case you can define a characteristic curve kink point, which has the following advantages:

- High k_V factor in the low range
- Low k_V factor in the upper range (beyond the machining velocity range)
- ▶ Define the position of the characteristic kink with MP1830.x. In the upper range, the k_V factor is multiplied by the factor from MP1820.x.
- ▶ Enter a multiplier in MP1820.



The characteristic curve kink point must lie above the tool feed rate!

Calculating the lag (following error):

$$s_a = \left(\frac{\text{MP1830.x [\%]}}{\text{100 [\%]}} + \frac{\text{100 [\%]} - \text{MP1830.x [\%]}}{\text{MP1820.x} \cdot \text{100 [\%]}}\right) \cdot \frac{v_e}{k_V}$$

MP1820.x **Multiplier for the k_V factor**
Input: 0.001 to 1.000 00

MP1830.x **Characteristic curve kink point**
Input: 0.000 to 100.000 [%]

Opening the position control loop

If M4581 has been set, the control opens the loops of all axes and of the spindle, and then performs an NC stop. This makes it possible, for example, to open the position control loops and at the same time switch off the drives. As with an external emergency stop, position monitoring is shut off for the time defined in MP1150.1, and an actual-to-nominal value transfer is executed. After the time defined in MP1150.1 has expired, position monitoring is again active, for at least the time defined in MP1150.2.

If at a standstill or with an external stop, the PLC sets M4581 in the Program Run Full Sequence, Program Run Single Block, or Positioning with MDI operating modes, and then the axes are moved, the **Approach position** function will be activated when the PLC resets M4581.
If MP4020 bit 8 = 1, then, if the axes are moved after an emergency stop, "Approach position" is automatically activated.

If M4580 has been set, an external EMERGENCY STOP (X42, pin 4 "control-is-ready") **is not** reported to the NC, but rather the function is executed like M4581.

If the position control loop is opened, the axis release in W1024 is canceled.

		Set	Reset
M4580	**Suppress EMERGENCY STOP, open all position control loops, NC stop**	PLC	PLC
M4581	**Open all position control loops, NC stop, activate "Approach position"**	PLC	PLC
W1024	**Axis release** Bits 0 to 8 represent axes 1 to 9 0: Position control loop open 1: Position control loop closed	NC	NC

MP1150.1 Time period for which the monitoring function is to remain off after the fast PLC input defined in MP4130.0 is set

Input: 0 to 65.535 [s]
Recommended: 0.2 to 0.5

MP4020 PLC Functions

Input: Bit 8 – Behavior after an external emergency stop
0: "Approach position" is not automatically activated
1: "Approach position" is automatically activated

Clamping the axes

After running an NC block you can clamp the axes:

- Wait until "axis in position" is set in W1026.
- Clamp the axis or axes.
- Open the position control loop with W1040.
- With Module 9161, switch the drive off.

A waiting period is necessary between "axis clamping" and "position control loop opening."

- In W1038, set the bit for the corresponding axis.

The next NC block is not run until the positioning window has been reached and the position control loop has been opened with W1040.

If the position control loop is opened, the axis release in W1024 is canceled. You can link switching off the drives via Module 9161 with W1024.

If a clamped axis is to be repositioned, the NC cancels the "axis in position" message in W1026:

- With Module 9161, switch the drive on.
- Release the clamping.
- Close the position control loop with W1040.

		Set	Reset
W1038	**Preparing opening of the position control loop** Bits 0 to 8 represent axes 1 to 9 0: Not active 1: Active	PLC	PLC
W1040	**Axis-specific opening of the position control loop** Bits 0 to 8 represent axes 1 to 9 0: Do not open the position control loop 1: Open the position control loop	PLC	PLC

Feed-rate enable

To move the axes, you must first enable the feed rate through the PLC. Until "feed-rate enable" is set, the nominal velocity value zero is output. "F" is highlighted in the status display.

Feed-rate enable for all axes:

- Set M4563.

Axis-specific feed-rate enable:

- Reset M4563.
- In W1060, set the corresponding bits.

		Set	Reset
M4563	**Feed-rate enable for all axes**	PLC	PLC
W1060	**Axis-specific feed-rate enable** Bits 0 to 8 represent axes 1 to 9 0: No feed-rate enable 1: Feed-rate enable	PLC	PLC

Actual-to-nominal value transfer

During actual-to-nominal value transfer, the current position is saved as the nominal position value. This becomes necessary, for example, if the axis has been moved when the position control loop is open.

There are two ways to turn the actual position into the nominal position:

- To transfer the actual position value in the MANUAL and ELECTRONIC HANDWHEEL modes, set the corresponding bit in W1044.
- To transfer the actual position in all operating modes, use Module 9145.

Warning

Ensure that actual-to-nominal value transfer does not occur continually, since the position monitoring will not be able to detect any uncontrolled machine movements. In this case no safe machine operation would be possible.

		Set	Reset
W1044	**Actual-to-nominal value transfer** Bits 0 to 8 represent axes 1 to 9 0: No actual-to-nominal value transfer 1: Actual-to-nominal value transfer	PLC	PLC

Module 9145 Actual-to-nominal value transfer

An actual-to-nominal value transfer for NC axes, or for PLC and NC axes together, is possible only if the control is not active (M4176 = 0) or if there is an M/S/T/T2/G strobe.

The module can always be called for an actual-to-nominal transfer only for PLC axes.

For a transfer via M strobe, MP7440 bit 2 must not be set. For a transfer via S/G strobe, MP3030 must not be set.

Call:

```
PS    B/W/D/K   <Axes bit-encoded>
CM    9145
```

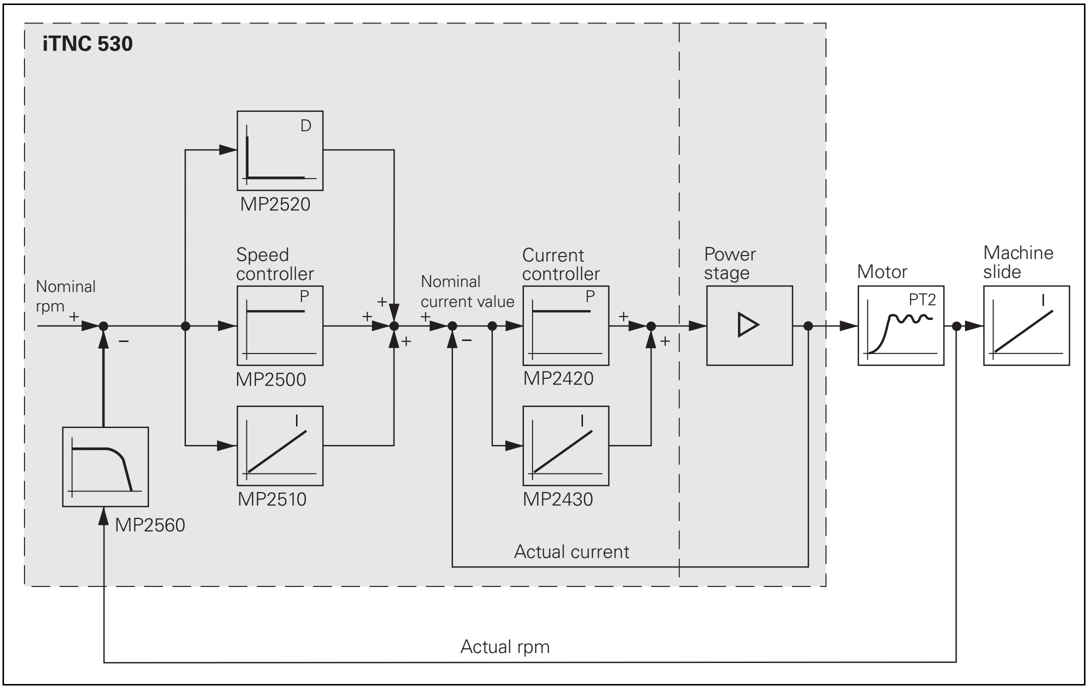
Error detection:

Marker	Value	Meaning
M4203	0	Actual value was assumed as nominal value
	1	Error code in W1022
W1022	2	Invalid axis number
	21	Missing M/S/T/T2/G strobe in M4176 = 1
	24	Module was called in a spawn job or submit job

6.8.4 Speed Controller

6, 10 or 12 digital speed controllers for the axes and spindle(s) are integrated in the iTNC 530:

The actual speed values are measured directly at the motors with HEIDENHAIN rotary encoders. The position controller provides the nominal speed value. The speed controller is driven by the difference between nominal and actual speed values. It provides the nominal current value as output.



See "Commissioning" on page 6 – 234.

With Module 9164 you can read the actual speed value of the motors.

You can adjust the step response of the speed controller:

- With the position controller switched off, enter with MP2500.x a proportional factor and with MP2510.x an integral factor for the speed controller. Adjust the step response so that only one overshoot is visible and the settling time t_{off} is as small as possible.
  Realistic values for the settling time: 3 ms to 15 ms

MP2500.x **Proportional factor of the shaft speed controller**
Input: 0 to 1 000 000.000 [As]

MP2510.x **Integral factor of the shaft speed controller**
Input: 0 to 100 000 000 [A]

Module 9164 Reading the actual speed value of the motor

The resolution of the actual speed value depends on the encoder being used:

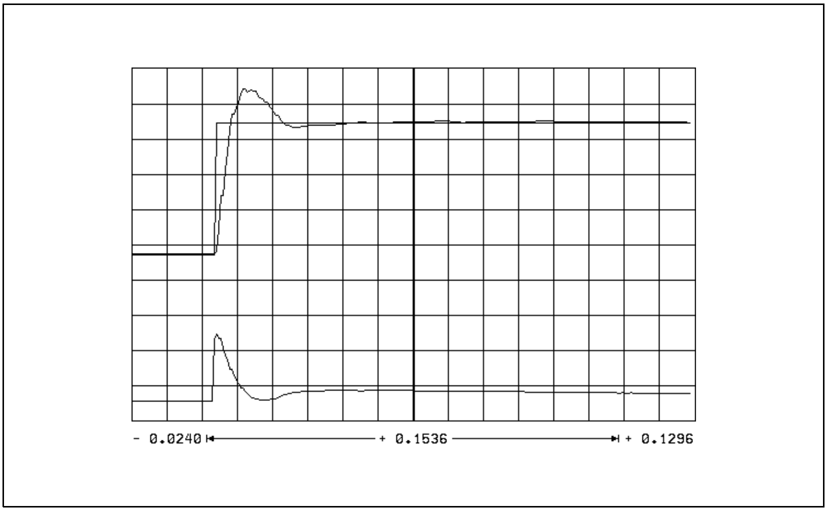
$$\text{Resolution} = \frac{1}{\text{Line count} \cdot 1024} \cdot 100\,000 \text{ [rpm]}$$

Call:

PS	B/W/D/K	<Axis> 0 to 8: Axes 1 to 9 15: Spindle
CM	9164	
PL	B/W/D	<Actual speed value in the format 0.001 [rpm]>

Error detection:

Marker	Value	Meaning
M4203	0	Actual speed value was read
	1	Control has no integrated current controller



The step response illustrated above is idealized. In practice, interfering oscillations are superimposed on the step response.

You can reduce these interference oscillations with the differential factor, the PT_2 second-order time-delay element, the band rejection filter and the low-pass filter of the speed controller.

Differential factor

The differential factor can reduce low-frequency oscillations. However, it increases oscillations in the high frequency range.

▶ In MP2520.x, enter a differential factor.

> **Note**
>
> Ensure that the system is stable enough!
>
> The differential factor is not recommended on machines with motors that have belt couplings. The influence of aging and temperature is too great.

Estimating the differential factor:

$$\text{MP2520.x} \approx \frac{T \cdot \text{MP2500.x}}{8}$$

MP2520.x: Differential factor of the speed controller [As^2]
MP2500.x: Proportional factor of the speed controller
T: Period of the lowest interference frequency [s]

MP2520.x **Differential factor of the shaft speed controller**
Input: 0 to 1.0000 [As^2]

Low-pass filter

With the low-pass filter you can damp high-frequency oscillations (> approx. 600 Hz):

▶ Use the oscilloscope to find the fundamental frequency of the iTNC.

▶ Activate the 1st or 2nd order low-pass filter (see table).

Fundamental frequency of the interference oscillation	Filter order (MP2560.x)
600 Hz to 700 Hz (approx.)	First order (MP2560.x = 1)
> 700 Hz (approx.)	Second order (MP2560.x = 2)

If you cannot achieve satisfactory results with the low-pass filter, try the PT_2 element.

MP2560.x **Low-pass filter of the speed controller**
Input: 0: No low-pass filter
1: 1st-order low-pass filter
2: 2nd-order low-pass filter

PT_2 element of the speed controller

If the controlled system is insufficiently damped (e.g. direct motor coupling or roller bearings), it will be impossible to attain a sufficiently short settling time when the step response of the speed controller is adjusted. The step response will oscillate even with a low proportional factor:

- In MP2530.x, enter a value for damping high-frequency interference oscillations. If the value you choose is too high, the k_V factor of the position controller and the integral factor of the speed controller is reduced. Realistic input values: 0.0003 to 0.0020

MP2530.x **PT_2 element of the speed controller (2nd-order delay)**
Input: 0 to 1.0000 [s]

Band-rejection filter

With the band-rejection filter you can damp oscillations that you cannot compensate with the differential factor, the PT_2 element, or the low-pass filter:

- With the oscilloscope of the iTNC, find the fundamental frequency of the interference oscillations and enter them in MP2550.x.
- Increase MP2540.x incrementally until the interfering oscillation is minimized. If you set the damping too high, you will limit the dynamic performance of the control loop. Realistic input values: 3 to 9 [dB]

MP2540.x **Band-rejection filter damping of the speed controller**
Input: 0.0 to 18.0 [dB]

MP2550.x **Band-rejection filter center frequency of the speed controller**
Input: 0.0 to 999.9 [Hz]

Active damping of low-frequency oscillations

The active damping of low-frequency oscillations is suitable for damping noise oscillations up to approx. 30 Hz. The damping factor is set in MP2607.x, and the damping time constant in MP2608.x. It can be calculated according to the following formula:

$$MP2608.x = \frac{k}{2 \cdot \pi \cdot f}$$

k: Factor from 0.8 to 1.0
f: Frequency to be damped (< approx. 30 Hz)

Note

The active damping should only be used if improvements actually occur, since the damping could also lead to lower and higher frequencies being fortified.

Activating the active damping:

- Ascertain the deepest resonant frequency (e.g. with the frequency diagram in TNCopt when adjusting the IPC and k_V factor).
- Set MP2607.x = 1.5.
- Calculate the damping time constant according to the above formula with k = 0.9, and enter this value in MP2608.x.
- Record **`I (n int)`** or **`s diff`** with the integrated oscilloscope, and move the axis with the axis-direction buttons.
- Vary the value of *k* up and down somewhat (between 0.8 and 1.0), calculate MP2608.x, and compare the oscilloscope recordings in order to find the correct value for MP2608.x (the value with the lowest amplitude).
- Vary MP2607.x, and compare with the recordings in the frequency diagram in TNCopt for the adjustment of the IPC and k_V factor.
- Select the value for MP2607.x by evaluating the advantages and disadvantages of the active damping.

MP2607.x **Damping factor for active damping**
Input: 0 to 30.000
0: No damping
1.5: Typical damping factor

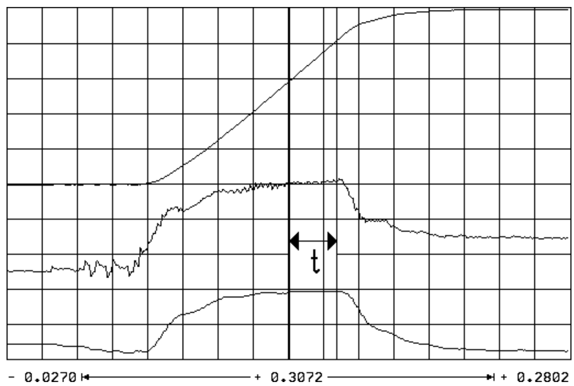
MP2608.x **Damping time constant for active damping**
Input: 0 to 0.9999 [s]
0: No damping
0.005 to 0.02: Typical damping time constant

Acceleration feedforward

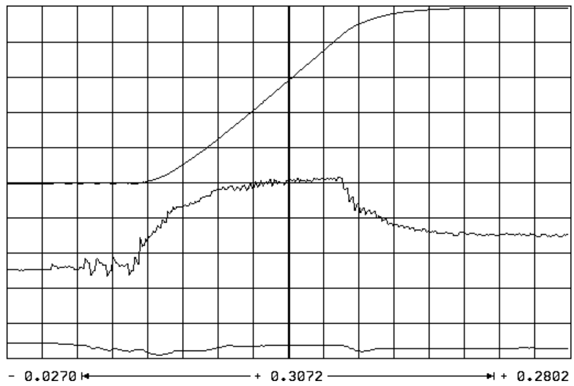
Acceleration feedforward functions only in velocity feedforward control in parallel with the speed controller.

At every change in velocity, spikes of short duration appear in the following error. With acceleration feedforward control you can minimize these spikes:

- First adjust the friction compensation. Enter values in MP2610.x to MP2620.x.
- From the integral-action component of the nominal current value I (INT RPM) calculate the input value for MP2600.x.
- Adjust the acceleration feedforward control with MP2600.x.



MP2600 = 0



MP2600.x at optimum setting

For calculation of the acceleration feedforward, the integral-action component of the nominal current value I (INT RPM) is recorded with the internal oscilloscope. The actual speed value V (ACT RPM) and nominal current value I NOMINAL are also recorded for better illustration.

$$\text{MP2600.x} = \frac{\text{I (N INT) [A]} \cdot \text{t [s]} \cdot \text{60 [s/min]} \cdot \text{MP2020.x [mm]}}{\Delta\text{V (N IST) [mm/min]}}$$

I (INT RPM) = integral-action component of the nominal current value

t = acceleration time in which I (INT RPM) remains constant

ΔV (ACT RPM) = actual speed value during change

MP1054.x = traverse distance per motor revolution

MP2600.x **Acceleration feedforward**
Input: 0 to 100.0000 [A/(rev/s^2)]

Limiting the integral factor

In machines with a great deal of stiction, a high integral-action component can accumulate if there is a position error at standstill. This can result in a jump in position when the axis begins moving. In such cases you can limit the integral-action component of the speed controller:

- Enter a limit in MP2512.x.
  Realistic input values: 0.1 to 2.0

MP2512.x **Limiting the integral factor of the speed controller**
Input: 0.000 to 30.000 [s]

Integral Phase Compensation IPC

An I factor can be set in the speed controller of the iTNC (MP2510.x). This I factor is needed to attain a short setting time. However, the I factor has a negative influence on the position controller, i.e. the position controller tends to oscillate more easily, and it is often impossible to set the k_V factor (MP1510.x) high enough.
The IPC (Integral Phase Compensation) compensates the negative influence of the I factors on the speed controller, and makes it **possible** to increase the k_V factor (MP1510.x).

The IPC is beneficial on the following types of machines:

- Machine type 1: Machines with a dominant natural frequency between 15 Hz and 80 Hz, for which it is not possible to set a sufficiently high k_V factor.
- Machine type 2: Small-to-medium size machines that are driven directly.

Note

- The acceleration feedforward (MP2600.x) must already have been carefully adjusted for both types of machines.
- If after commissioning the IPC you wish to optimize the speed controller again, you must switch off the IPC beforehand, because the IPC influences the curve form.
- Use the same test program to commission the IPC as is used to measure the jerk and the k_V factor.

Machine type 1:

- The machine is commissioned as usual until the k_V factor is to be determined.
- Enter MP2602.x = 1 and MP2604.x = 0.
- Increase the k_V factor (MP1510.x) until you reach the oscillation limit.
- Starting value: $\text{MP2604.x} = \frac{2}{3} \cdot \frac{\text{MP2600.x}}{\text{MP2500.x}}$
- Change MP2604.x until you have found the maximum k_V factor (MP1510.x). If you cannot find a maximum k_V factor, use the default value in MP2604.x.
- Starting value: $\text{MP2602.x} = \frac{\text{MP2600.x}}{\text{MP2500.x}}$
- Increase MP2602.x until you have found a maximum k_V factor (MP1510.x). If the value found for MP2602.x is significantly greater than the starting value (> factor 2), you should adjust MP2604.x again by enlarging and reducing it to find the optimum value.
- MP1510.x = 0.65 · ascertained k_V

Machine type 2:

- The machine is commissioned as usual until the k_V factor is to be determined.
- Enter MP2602.x = 1 and MP2604.x = 0.
- Increase the k_V factor (MP1510.x) until you reach the oscillation limit.
- Starting value: $MP2604.x = \frac{2}{3} \cdot \frac{MP2600.x}{MP2500.x}$
- Change MP2604.x, normally by reducing it, until the following error is at its minimum.
- MP1510.x = 0.65 · ascertained k_V

MP2602.x **IPC time constant T_1**
Input: 0.0001 to 1.0000 [s]
0: IPC inactive

MP2604.x **IPC time constant T_2**
Input: 0.0001 to 1.0000 [s]
0: IPC inactive

Minimizing the following error during the jerk phase

An increased following error during the jerk phase can be minimized with MP2606.x. The preceding adjustment of the IPC must have been carried out for this to function.
The typical entry value for MP2606.x is between 0.5 and 2.

Commissioning:

- Enter the following test program:

```
0 BEGIN PGM TEST MM
1 LBL 1
2 L X <maximum traverse> R0 FMAX
3 L X0 FMAX
4 CALL LBL1 REP 10/10
5 END PGM TEST MM
```

- Run the program at high speed.
- Use the integrated oscilloscope to record the following error.
- Change MP2606.x until a very small following error occurs in the jerk phase (positive following error: MP2606.x > 1, negative following error: MP2606 < 1)

MP2606.x **Following error in the jerk phase**
Input: 0.000 to 10.000

Holding torque

The holding torque is the torque that is required to keep a vertical axis at a standstill.

The holding torque is given by the iTNC through the integral-action component of the nominal current value. In most cases the holding torque is constant. The required holding current can therefore be fed forward through MP2630.x. This relieves the speed controller.

- To prevent the effect of stiction, measure the current at low speed in both directions (e.g. 10 rpm).
- Calculate the holding current from the mean of the measured current values and enter the result in MP2630.x.

Mean:

$$\text{MP2630.x} = \frac{\text{I NOML}_1 + \text{I NOML}_2}{2}$$

Note

If the ready signal (RDY) is missing from the speed encoder inputs of vertical axes, the DSP error message **`8B40 No drive release <axis>`** appears.
A vertical axis is defined with an entry in MP2630.x.

MP2630.x Holding current
Input: -30.000 to +30.000 [A]

6.8.5 Enabling the Drive Controller

At X51 to X62 the ready signal is available at pin 10b. As soon as the readiness signal is reset, the drive controllers are switched off. Normally, the error message **MOVEMENT MONITORING IN <AXIS> B** is output through the position control loop. Subsequently, the PWM signal release is switched off by the reset signal.

The drive controller cannot be switched on if the ready signal of the inverter, the global drive enabling through I32 (X4/33) or the axis group enabling through X150/151 is missing. To switch on the drive controller:

- Determine the functionality of the global drive enabling through I32 (X42/33) with MP2050.
- Assign 24 Vdc to pin 33 (I32) of connection X42 to enable the control.
- In MP2040.0 to MP2040.2, define the axis groups for drive enabling through X150/X151 pin 1 to pin 3 (e.g., MP2040.0 = %00000000000111 determines drive enabling for axes 1 to 3 via axis group 1). Depending on the control loop being used, either X150 and/or X151 must be wired (See "X150, X151: Drive controller enabling for axis groups" on page 3 – 26). Use Module 9157 to interrogate the status of X150/X151.
- Set W524 bit 0=1, so that X150/151 is interrogated in the position controller cycle.

Note

If you do not want to use drive enabling for axis groups, but rather just global drive enabling through I32 (X42/33), set all bits in MP2040.x to %00000000000000 and in W524 to zero.

- Activate the drive controllers with module 9161. You can use, for example, the axis release W1024 as a criterion for drive enabling.

Note

As of NC software 340 420-06 the current controller is switched on 50 ms after the controller is switched on (Module 9161). This also delays the acknowledgment over Module 9162 by 50 ms.

If you disconnect the voltage for

- X42/33, all drive controllers are switched off.
- X150/151, the drive controllers of the corresponding axis group(s) are switched off.

Note

If drive enabling through X150/151 or X42/33 is missing, the error message **8B40 No drive release <axis>** appears.

You can define axes for which the drives will not switch off if the global drive enabling through I32 (X42/33) is missing:

- Determine the functionality of the global drive enabling through I32 (X42/33) with MP2050.
- With Module 9169 transfer in bit code the axes that are not to be switched off.

You can determine by PLC which axes are switched off in 200 ms:

- Call Module 9159. The drives that are switched off are returned in bit code.

You can request the status of the drive controller with Module 9162, and you can determine if the drive controller is ready to be switched on with Module 9157.

The iTNC monitors the time between the switch-on of the drive controller and the READY signal of the power module (from the PWM cable). If the READY signal is missing after the waiting time has passed, the error message **`8B40 No drive release <axis>`** appears.

- Enter the permissible time in MP2170.

MP2040	**Axis groups for drive enabling through X150/X151**
Format:	%xxxxxxxxxxxxxx
Input:	0: Axis not assigned 1: Axis assigned
MP2040.0-2	Axis group 1 to 3
MP2040.3-7	Reserved, enter %00000000000000
MP2050	**Functionality of drive enabling I32 (X42/33)**
Input:	0: Emergency stop for all axes, Module 9169 not effective 1: Emergency stop for all axes that are not excepted with Module 9169 2: I32 and Module 9169 have no function
MP2170	**Waiting time between the switch-on of the drive and the drive's standby signal**
Input:	0.001 to 4.999 [s] 0: 2 [s]

		Set	Reset
W524	**Definition of X150/X151** Bit 0=1: X150/151 is interrogated in the position controller cycle Bit 1 to bit 15: Non-functional	PLC	PLC

Module 9157 Drive controller status

Status information about the drive controller can be ascertained with this module.

Call:

PS B/W/D/K <Status information>
0: Drive controller readiness
1: Drive controller status (as in Module 9162)
2: Via X150/X151, axis enabled (bits 0 to 13 = 1) or axis not enabled (bits 0 to 13 =0)
3: Signal to X150/X151
(bits 0 to 7 = X150; bits 8 to 15 = X151)
4: Spindle in operating mode 0 (bit 15 = 0) or operating mode 1 (bit 15 = 1)

CM 9157

PL B/W/D <Axis status information bit-encoded>

Error detection:

Marker	Value	Meaning
M4203	0	Status information was ascertained
	1	Error code in W1022
W1022	2	Invalid status information was programmed
	24	Module was called in a spawn job or submit job

Module 9159 Drives that are switched off in 200 ms

Call:

CM 9159

PL W/D <Drives, in bit code, that are switched off in 200 ms>

Module 9161 Enabling the drive controller

With this module you can switch the drive controllers (speed and current controllers) on and off for specific axes. A nominal speed value is also output when the drive controller is not enabled.

Call:

PS W/D/K <Released axes>
Bit: 15 876543210
Axis: S xxxx 987654321
0: No drive controller enabling
1: Drive controller enabling

CM 9161

Error detection:

Marker	Value	Meaning
M4203	0	No error
	1	Control has no current controller, or the call is in a spawn or submit job

Module 9162 Status request of the drive controller

Call:

CM	9162	
PL	B/W/D	<Drive is ready>
		Bit 15 0
		Axis Sxxxxxx987654321
		0: Not ready
		1: Ready

Module 9169 Axes for which I32 does not switch off the drives

Call:

PS	B/W/D/K	<Axes bit-encoded>
CM	9169	

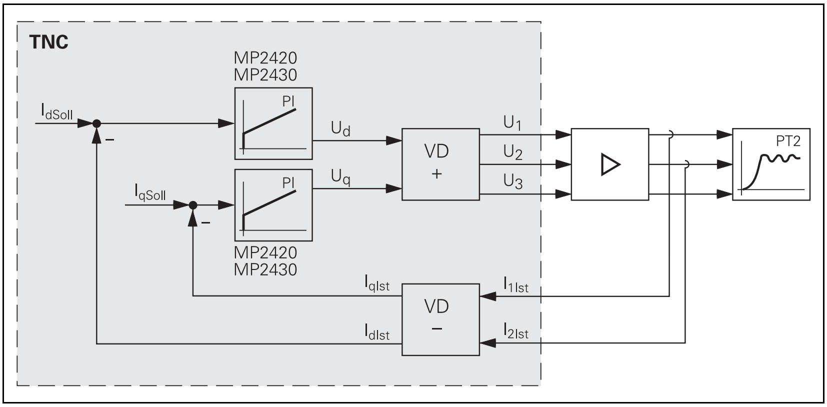
6.8.6 Current controller

6, 10 or 12 digital current controllers for the axes and spindle(s) are integrated in the iTNC 530.

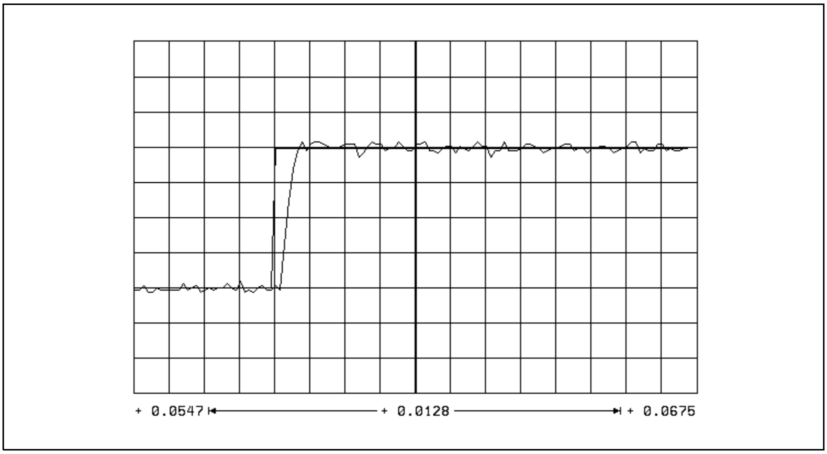
The nominal values for magnetizing current I_{dnom} and torque-producing current I_{qnom} are divided into the PWM signals U_1, U_2 and U_3 through a PI controller and vector rotator VD+, and are transferred to the power module through X51 to X60.

The actual current values I_{1act}, I_{2act} and I_{3act} are determined by the power module and are transferred to vector rotator VD– through X51 to X60. The vector rotator determines the actual values of magnetizing current I_{dist} and torque-producing current I_{qnom}.

Circuit diagram:



You adjust the current controller to attain the optimum result, with the position and speed controller switched off.



The step response is adjusted such that there is no overshoot and the rise time is as small as possible:

- In MP2420.x, define the P factor of the current controller.
- In MP2430.x, define the I factor of the current controller.

MP2420.x **P factor of the current controller**
Input: 0 to 9999.99 [V/A]

MP2430.x **I factor of the current controller**
Input: 0 to 9 999 999 [Vs/A]

6.8.7 Braking the Drives for an Emergency Stop and a Power Fail

In an emergency stop and power failure the spindle must be braked as quickly as possible. If the braking energy cannot be drawn off quickly enough, the dc-link voltage increases sharply. Under circumstances, the inverter could switch off and the spindle coast to a stop. A powerful braking of the spindle also leads to a high strain on the mechanics of the machine. Preferably the spindle should be braked in an emergency stop by limiting the braking power.

Note

Limiting the braking power is also effective when braking the spindle with M05, if the brake ramp in M05 (MP3411 and MP3412) is steeper than the brake ramp when limiting the braking power.

Normally, in case of an emergency stop, the axes are braked at the limit of current. This can create problems:

- With gantry axes a mechanical offset can occur between the master and slave axes.
- A gear between spindle and motor can be overloaded.

In such cases, the axes should preferably be braked in an emergency stop by adding an additional braking ramp.

Note

Both of the above braking strategies are possible for axes and spindles. If both braking strategies are activated for an axis or spindle, they do not exclude each other; this means that in case of an emergency stop, whichever strategy responds first takes effect.

Problems with inverters **without** regenerative power supplies (with braking resistors) during braking mostly arise if the inverter is switched off too early. The strain on the mechanics during braking is reduced, but can also be influenced with braking strategies.
Inverters **with** regenerative power supplies usually do not develop problems if they are switched off. The main concern here is for the mechanics of the machine. If the maximum regenerative power of the inverter is exceeded when braking the drives (during an emergency stop, for example), the axes and spindle(s) coast to a stop. In this case it is sensible to define separate maximum braking powers for each drive in MP2390.x. This will ensure that each drive is braked as quickly as possible.

Braking the axes by entering an additional braking ramp

In this strategy, the braking ramp to be used in an emergency stop is entered.

Set the axis braking ramp for an emergency stop:

- Enter as a minimum value in MP2590.x $= \frac{\text{MP1060.x} \cdot 60}{\text{MP1054.x}}$ On
- Use the emergency stop to brake the axis from rapid traverse.
- Increase the value entered in MP2590.x until the braking time is as short as possible and the mechanics of the axis are not overloaded.

If the value entered is too small, i.e. if braking is too slow, the axis brakes at the acceleration defined in MP1060.x.

Note

The value entered in MP2590.x refers to the motor speed, meaning the ballscrew pitch is not considered.

MP2590.x **Braking ramp in an emergency stop**
Input: 0.1 to 999.9 [rpm/ms]
0: Function inactive

Braking the spindle/spindles by entering the braking power

In this strategy the maximum braking power for braking the spindle/spindles in an emergency stop or power failure is entered.

If power limiting (MP2392.x) is used in normal operation, then the maximum braking performance is limited to the lower of the two values from the power limiting and the braking power.
Example:

Function	Case 1	Case 2
Power limiting (MP2392.x)	10 kW	5 kW
Maximum braking power (MP2390.x, MP2394.x)	5 kW	10 kW
Limiting the braking performance to	5 kW	5 kW

Braking the spindle/spindles in an emergency stop

- For **inverters with regenerative power supply**, enter MP2390.x = 0 so as not to limit the braking power.
- Calculate for **inverters with braking resistors** the input value for MP2390.x from the following formula:

$$\text{MP2390.x} = \frac{U_Z^2}{R \cdot 1000}$$

R = Braking resistance [Ω]
(PW 110, PW 210 = 18 Ω, PW 120 = 10 Ω, UP 110 = 9 Ω)
U_Z = dc-link voltage [V]
(UV 130, UE 2xx, UE 2xxB = 565 V; UV 120, UV 140 = 650 V)

Braking the spindle/spindles during a power fail

During a power fail, the "SH1B" signal on X51 to X60 is maintained for 3 more seconds, in order to brake the spindle/spindles. At the same time, the control tries to reset the PLC outputs.

- If you are using an additional braking resistor (e.g. UP 110) in connection with an **inverter with regenerative power supply,** calculate the value to be entered in MP2394.x from the above formula.
- Calculate for **inverters with braking resistors** the input value for MP2394.x with the above formula.

Note

If after entry of a value in MP2390.x or MP2394.x the mechanics are overloaded by the braking process, lower the value in MP2390.x or MP2394.x until you have found an optimum between braking time and mechanical loading.

MP2390.x **Maximum braking power**
Input: 0: No limiting of the braking power in an emergency stop
0.001 to 3000.000 [kW]

MP2394.x **Maximum braking power during a power fail**
Input: 0: No limiting of the braking power in a power failure
0.001 to 3000.000 [kW]

6.8.8 Power and Torque Limiting

You can limit the power of your spindle motor to achieve wider gear ranges. Wide-range motors are characterized by a larger speed range with higher torque at low speed.
One solution for bringing about this behavior is to use an oversized motor, and to limit the maximum power. However, power limiting does not reduce the high torque to the speed at which power limiting becomes effective. This high torque (until power limiting takes effect) can be reduced with torque limiting, in order to keep the mechanics of the machine from becoming overloaded.

With torque limiting you can also limit the torque of the axis motors, in order to keep the mechanics of the machine from becoming overloaded. Power limiting is not useful for axis motors.

For **axes and spindles**, the torque is limited to the value taken from either the table of power modules or the motor table, whichever is lower.

If a non-HEIDENHAIN inverter or a UE 2xx HEIDENHAIN compact inverter is used, the maximum torque current , and as a result the maximum torque, is limited to 70% of the maximum current, since these inverters do not provide any signal for an excessive dc-link current.
The modular HEIDENHAIN inverter system or the UE 2xxB HEIDENHAIN compact inverters do provide such a signal (ERR-IZ). As a result, the maximum torque current is not limited.
This monitoring function must be set for the respective inverter in MP2220.x bit 2.

The torque can be calculated for any speed:

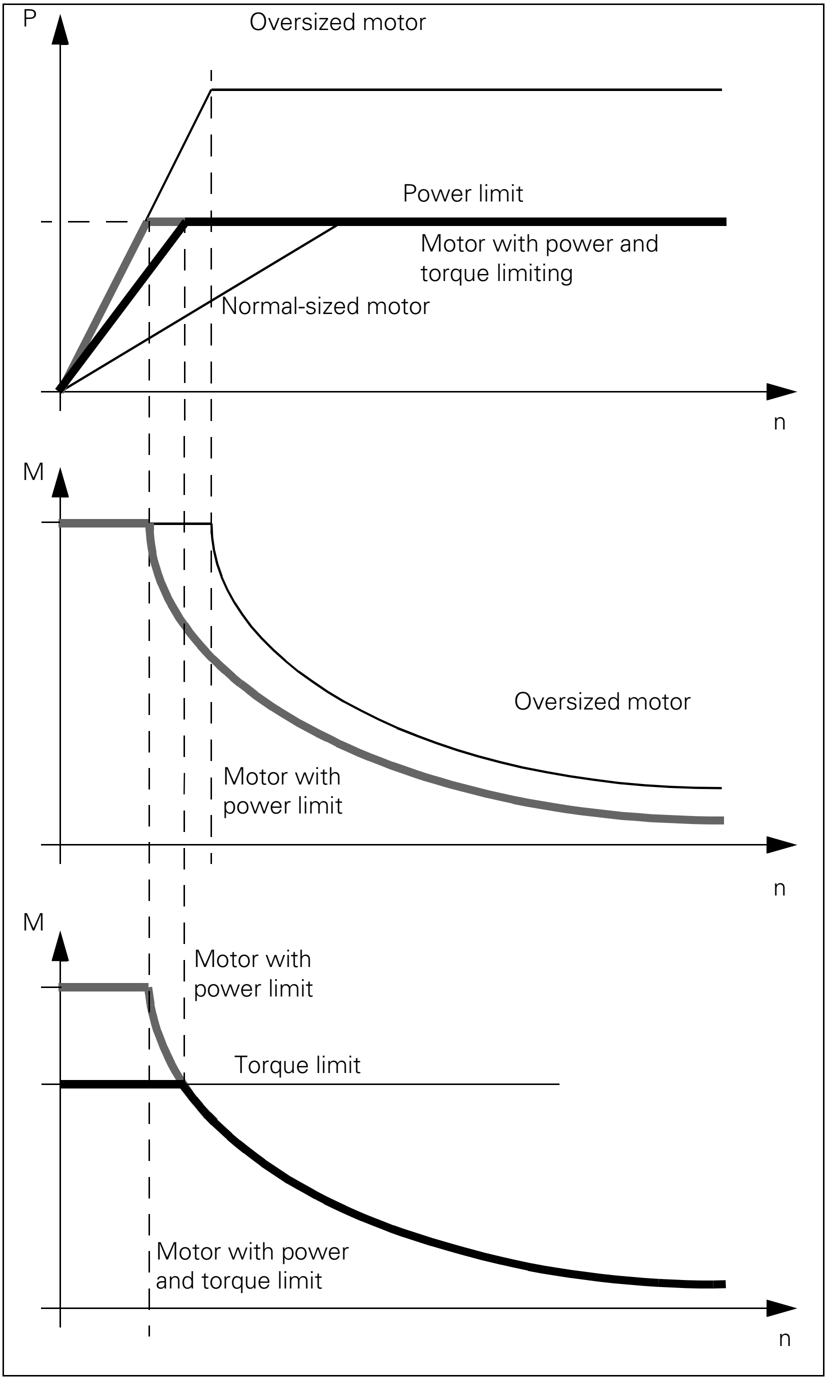
$$M = \frac{P \cdot 60}{n \cdot 2 \cdot \pi}$$

M: Torque [Nm]
P: Power [W]
n: Speed [rpm]

Note

The power and torque limiting can have an effect on the braking of the spindle in an emergency stop.

- Enter the maximum power for the spindle in MP2392.x.
- Enter the maximum torque for the spindle or axis in MP2396.x.
- For the **modular HEIDENHAIN inverter system** or the **UE 2xxB** compact inverter, activate the monitoring of the ERR-IZ signal with MP2220.x bit 2 = 1.
  For **non-HEIDENHAIN inverters** or the **UE 2xx HEIDENHAIN compact inverter**, deactivate the monitoring of the ERR-IZ signal with MP2220.x bit 2 = 0.


P
Oversized motor
Power limit
Motor with power and
torque limiting
Normal-sized motor
n
M
Oversized motor
Motor with
power limit
n
M
Motor with
power limit
Torque limit
Motor with power
and torque limit
n

MP2220.x **Monitoring functions**

Input: Bit 2 – Monitoring of the ERR-IZ signals (only with HEIDENHAIN inverters except for UE 2xx)
0: Inactive
1: Active

MP2392.x **Power limit**

Input: 0: No power limit
0.001 to 3000.000 [kW]

MP2396.x **Maximum torque**

Input: 0: No torque limiting
0.1 to 30 000.0 [Nm]

Module 9158 Maximum torque

With Module 9158 you can limit the torque of an axis or spindle. The maximum torque resulting from the data in the control’s motor table cannot be exceeded. In this case the torque is limited to the value from the motor specifications. After the drive is switched off, the original torque becomes effective again.
If the torque limit is active, the standstill monitoring is inactive; only the motion monitoring remains active.

The torque-producing current required for the desired torque must be transferred to the module:

Synchronous motor	Asynchronous motor
$I_q = \frac{M \cdot \sqrt{2}}{k_M}$ I_q: Torque-producing current M: Desired torque k_M: Torque constant (from motor table)	■ Armature control range ($n < n_{FS}$) $I_q = \frac{M \cdot n_N \cdot 2 \cdot \pi \cdot \sqrt{I_N^2 - I_0^2}}{P_N \cdot 60}$ ■ Field weakening range ($n > n_{FS}$) $I_q = \frac{M \cdot n_N \cdot n \cdot 2 \cdot \pi \cdot \sqrt{I_N^2 - I_0^2}}{P_N \cdot n_{FS} \cdot 60}$ I_q: Torque-producing current M: Desired torque n_N: Rated speed (from motor table) n: Current speed I_N: Rated current (from motor table) I_0: No-load current (from motor table) P_N: Rated power output (from motor table) n_{FS}: Threshold speed for field weakening (from motor table)

Call:

```
PS      B/W/D/K/S<Axis or spindle>
                  0 to 8: Axes 1 to 9
                  15: Spindle
PS      B/W/D/K/S<Torque-producing current in mA>
                  –1 = Torque given in motor specifications
CM      9158
```

Error detection:

Marker	Value	Meaning
M4203	0	Torque preset active
	1	Error code in W1022
W1022	1	0 Nm torque transferred
	2	Invalid axis number
	24	Module was called in a spawn job or submit job

6.8.9 Synchronous Motors in Field Weakening Range

Synchronous motors can also be operated with a weakened field. This is necessary, for example, for high-speed synchronous spindle motors, since the inverter voltage is not sufficient at high speeds.

If the power supply fails, the dc-link voltage increases sharply. As a result, the inverters and possibly the motor might be damaged. A safety feature would be the use of a voltage protection module (e.g. SM 110, see the "Inverter Systems and Motors" Technical Manual).

Warning

A braking resistor, such as PW xxx or UP 110, does not offer sufficient protection.

For synchronous motors, the operation with a weakened field is automatically activated if MP2160.x = 1 or 2 has been entered. You do not need to make any further settings.

- Enter MP2160.x = 0 if you want to operate synchronous motors **without** a weakened field.
- Enter MP2160.x = 1 if you want to operate synchronous motors with a weakened field **and** use voltage protection modules.

The EcoDyn synchronous motors from HEIDENHAIN are operated with a limited field weakening. No voltage protection module is necessary here.

- Select from the motor table the motors with the designation **`QSY1xxx EcoDyn`** or **`QSY1xxx EcoDyn EnDat`** for MP2200.x.
- Enter MP2160.x = 2 if you are using EcoDyn synchronous motors from HEIDENHAIN.

MP2160.x	**Field weakening for synchronous motors**
Input:	0: No voltage protection module 1: Voltage protection module present 2: Limited field weakening without voltage protection module for EcoDyn motors

6.9 Offset Adjustment

Digital axes:

An offset adjustment at the output of the current controller is automatically compensated.

Analog axes:

The maximum permissible offset voltage in the control is 100 mV. If this voltage is exceeded, the error message **EXCESSIVE OFFSET IN <AXIS>** appears.

6.9.1 Offset Adjustment with Integral Factor

With the integral factor you can adjust an offset automatically:

- Enter an integral factor in MP1080.x. The speed with which the offset is eliminated depends on the size of the factor.
- Play in the drives can result in instability in the control loop.
  In this case, enter the factor zero.

MP1080.x is effective only at a standstill.

MP1080.x	**Analog axes: Integral factor for offset adjustment**
Input:	Input 0 to 65 535
	Digital axes: No function
	Input: 0

6.9.2 Offset Adjustment by Code Number

- Activate the offset adjustment with the code number 75 368.

The iTNC displays the offset values of the analog axes in the dialog line. The values show the setting of the voltage in 0.15-mV steps.
Display value 10 means: 10 · 0.15 mV = 1.5 mV.
The displayed offset value consists of the offset values that are generated in the motor controller and in the control.

If the values are to be automatically compensated:

- Press the ENT key or the CONTINUE soft key. The control outputs a corresponding countervoltage.

If nothing is to be changed:

- Press the END soft key.

If the offset adjustment is to be switched off again:

- Enter the code number 75 368 and press the NO ENT key or the CANCEL soft key.

The offset values are saved in the control and remain safe in the event of power interruption. After a control is exchanged, the offset adjustment must be repeated by means of the code number.

6.10 Contouring Behavior

6.10.1 Radial Acceleration

You can define the radial acceleration of axes in addition to the simple acceleration (MP1060.x):

▶ Define the radial acceleration in MP1070.

MP1070 limits the feed rate during circular movement according to the formula:

$$v = \sqrt{r \cdot MP1070}$$

v = feed rate during circular movement [m/s]

r = radius [m] (of the path of the tool center)

HEIDENHAIN recommends:
MP1070 = 0,5...1 · MP1060

If the programmed feed rate is less than that calculated above, then the programmed feed rate becomes effective.

MP1070 functions for operation with both following error and feedforward control.

MP1070 **Radial acceleration**
Input: 0.001 to 100.000 [m/s^2 or $1000°/s^2$]

6.10.2 Contour Velocity at Corners

To comply with a defined tolerance, the iTNC can reduce the tool velocity before machining corners, line-to-arc transitions and arc-to-arc transitions. The control can react to a potential violation velocity tolerance up to 256 blocks in advance. This feature is known as “look-ahead”:

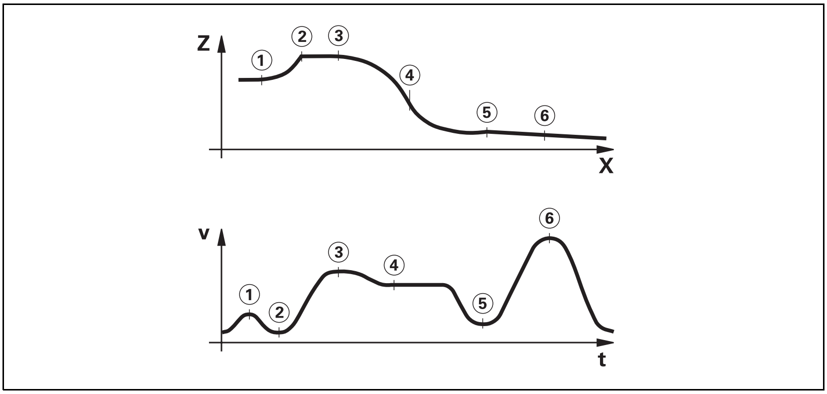
- Define the permissible tolerance for contour transitions in MP1096. The larger the tolerance, the greater the tool velocity.

The user can overwrite this tolerance with Cycle 32 “Tolerance.”

Jerk limitation (See "Interpolator" on page 6 – 117) and nominal-position-value filters enable the iTNC to machine 3-D surfaces at high speed. Prerequisite: The contour must be described with short line segments.

To ensure that cutter-compensated outside corners remain exact, a spline must be inserted into the cutter midpoint path instead of a transitional arc. The longer path of the spline (compared to the circle) results in an increased machining time. A spline also has the advantage of reducing the jerk:

- Enter bit 10 = 1 in MP7680.



Note

`FN17: SYSWRITE ID1020 NR1 = <value>` can be used from the NC program to activate machine parameter subfiles for various machining operations. See Page 9–22.

MP1096 **Tolerance for contour transitions**

Input: 0: No nominal position value filter
0.001 to 3.000 [mm]: Permissible tolerance at contour transitions

MP7680 **Machine parameter with multiple function**

Input: Bit 10 – Cutter-radius-compensated outside corners:
0: Insertion of a circular arc
1: Insertion of a spline curve
Proposed input value: %xx1xxxxxxxxxx
Bit 11 – Reserved

Rounding of corners

If you program M90, the tool velocity in following-error mode is kept constant at corners without radius compensation. This causes a corner rounding that varies with the feed rate (see User's Manual).

If you program M112 or M124, defined arcs will be inserted at the corners regardless of the feed rate (see User's Manual). The rounding arcs generate twice as many NC blocks, and the feed rate is now only limited by the radial acceleration.

- With MP7680 bit 7, specify whether the rounding arcs should always be inserted or only if the acceleration from MP1060.x or MP1070 has been exceeded at the corners.
- With MP7680 bit 8, specify whether a rounding arc or a cubic spline is to be inserted between lines during the M function M112. The feed rate is reduced enough to prevent any excessive jerk. This does not apply if F MAX is programmed. The cubic spline produces an additional jerk reduction. However, it requires a longer processing time than an inserted rounding, and due to the longer path of the spline (compared to the circle), the machining time also increases.

If you have set bit 8, you can specify with bit 9 whether the jerk will remain constant on the spline. The contour speed is adjusted for constant jerk.

MP7680 **Machine parameter with multiple function**
Input: Bit 7 – Insertion of a defined rounding arc or spline:
0: Defined rounding arcs are always inserted
1: Defined rounding arcs are always inserted if the acceleration from MP1060.x or MP1070 was exceeded.
Bit 8 – Insertion of a rounding arc or cubic spline:
0: Rounding arc is inserted.
1: A cubic spline is inserted instead of a rounding arc.
Bit 9 – Constant jerk on spline (Bit 8 = 1):
0: No constant jerk
1: Constant jerk

6.11 Monitoring Functions

The NC monitors the axis positions and the dynamic response of the machine. If the fixed values are exceeded, it displays an error message and stops the machine.

With W1042 you can switch off the following types of monitoring for individual axes:

- Position monitoring
- Standstill monitoring
- Movement monitoring
- Nominal speed value monitoring

		Set	Reset
W1042	**Deactivation of monitoring functions** Bits 0 to 8 represent axes 1 to 9 0: Monitoring functions active 1: Monitoring functions inactive	PLC	PLC

Warning

Safe machine operation is not possible if the monitoring functions are switched off. Uncontrolled axis movements are not detected.

If the reaction time of the PLC for switching off the monitoring functions is not sufficient, you must use a high-speed PLC input. High-speed PLC inputs are interrogated within the position control loop cycle:

- In MP4130.0, enter the number of the PLC input that is to be defined as high-speed PLC input.

Note

The inputs of the PL 4xxB and PL 510 cannot be used as high-speed PLC inputs.

- Define in MP4131.0 the activation criterion for the PLC input specified in MP4130.0.
- Enable MP4130.0 with W522 bit 0. As soon as the input is set, the monitoring functions are switched off, the axes stopped, and the drive is switched off. If the following error is greater than MP1030.x (positioning window), the actual value is saved as nominal value. The monitoring functions become active again if the high-speed PLC input is reset or MP4130.0 has been disabled with W522 bit 0.

MP1150.1	**Time period for which the monitoring function is to remain off after the fast PLC input defined in MP4130.0 is set**
Input:	0 to 65.535 [s] Recommended: 0.2 to 0.5
MP4130.0	**Number of the high-speed PLC input for switching off the monitoring functions**
Input:	0 to 255 [no. of the PLC input] The inputs of the PL 4xxB and PL 510 may not be used!
MP4131.0	**Activation criterion for fast PLC input for switching off the monitoring functions**
Input:	0: Activation at low level 1: Activation at high level

		Set	Reset
W522	**Enabling the high-speed PLC inputs** Bit 0: Fast PLC input is defined in MP4130.0 for switching off the monitoring functions	PLC	PLC

6.11.1 Position Monitoring

The axis positions are monitored by the iTNC as long as the control loop is closed.

The input values for position monitoring depend on the maximum possible following error (servo lag). Therefore the input ranges for operation with following error and velocity feedforward are separate.

For both modes of operation there are two range limits for position monitoring.

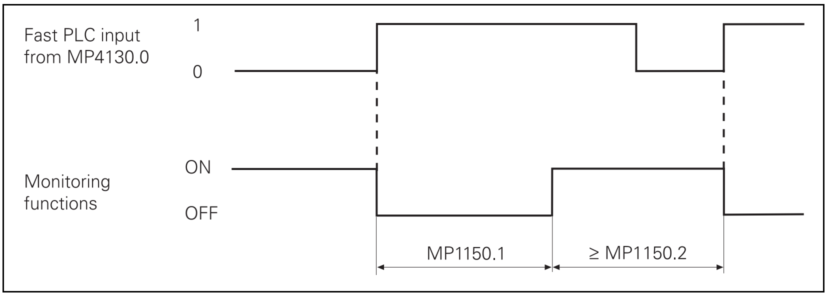
If the first limit is exceeded, the error message **EXCESSIVE SERVO LAG IN <AXIS>** appears. The machine stops.
You can clear this message with the CE key. An actual-to-nominal value transfer is then executed for the respective axes.

If the second limit is exceeded, the blinking error message **EXCESSIVE SERVO LAG IN <AXIS>** appears. The control-is-ready signal output is reset.
You cannot clear this message. You must restart the control to correct the error.

- In the machine parameters given below, define two range limits for position monitoring in each operating mode.
- Adjust the input values to the machine dynamics.

If blocked axes are the cause of the erasable error message **EXCESSIVE SERVO LAG IN <AXIS>,** a nominal velocity value may freeze, since the machine axes can no longer be moved:

- In MP1150.0, specify the time after which the nominal velocity value is to be deleted. After this time has expired, the actual position value is assumed as nominal position value. Before this time has expired, the error message cannot be cleared with the CE key. At this time the actual position value is assumed as nominal value, and the nominal velocity value is deleted.
- In MP1150.1, enter the time period for which the monitoring function is to remain off after the fast PLC input from MP4130.0 has been set. The monitoring functions reactivate after expiration of this time.
- In MP1150.2, specify the minimum time period after expiration of the time from MP1150.1 for which the monitoring functions should remain effective (e.g. if the input changes quickly).



MP1150	**Position monitoring**
MP1150.0	Delay time for deleting the nominal velocity value with the deletable error message: **`Excessive servo lag in <axis>`**
Input:	0 to 65.535 [s] Recommended: 0
MP1150.1	Time period for which the monitoring function is to remain off after the fast PLC input defined in MP4130.0 is set.
Input:	0 to 65.535 [s] 0: Monitoring functions on Recommended: 0.2 to 0.5
MP1150.2	Minimum time period for which the monitoring functions are to remain effective after expiration of the time from MP1150.1.
Input:	0 to 65.535 [s]

MP1410.x	**Position monitoring for operation with velocity feedforward control (erasable)**
Input:	0.0010 to 30.0000 [mm] Recommended: 0.5 mm

MP1420.x	**Position monitoring for operation with velocity feedforward control (EMERGENCY STOP)**
Input:	0.0010 to 30.0000 [mm] Recommended: 2 mm

MP1710.x	**Position monitoring for operation with following error (erasable)**
Input:	0.0000 to 300.0000 [mm] Recommended: 1.2 · following error

MP1720.x	**Position monitoring for operation with following error (EMERGENCY STOP)**
Input:	0.0000 to 300.0000 [mm] Recommended: 1.4 · following error

Difference between position at switch-on and shutdown

When the control is switched off, the actual position of the axes is saved with an absolute encoder. During switch-on it is compared with the position values read by the encoder.

If the positions differ by more than the difference defined in MP1146.x, a pop-up window appears with both positions. The new position must be confirmed with a soft key. If it is not confirmed, the error message **`Check the position encoder <axis>`** appears.

MP1146.x	**Difference between the position at shutdown and the position read in via the EnDat interface**
Input:	0.0000 to 300.0000 [mm] or [°] 0: No difference permitted

6.11.2 Nominal Speed Value Monitoring

For the axes, the nominal speed value monitoring is effective only in operation with velocity feedforward.

For the spindle, it is effective in operation with following error as long as the position control loop is closed (orientation).

If the nominal speed value calculated by the position controller is greater than the maximum possible nominal value, the blinking error message **NOMINAL SPEED VALUE TOO HIGH <AXIS>** appears and the control-is-ready output is reset.

Analog axes: Maximum nominal value = 10 V

Analog spindle: Maximum nominal value = 20 V

Digital axes and spindle: Maximum nominal value = maximum motor speed from motor table

6.11.3 Movement Monitoring

Movement monitoring is possible during operation both with velocity feedforward and with following error.

During movement monitoring, the actual path traveled is compared at short intervals (several servo cycles) with the nominal path calculated by the NC. If during this period the actual path traveled differs from the calculated path, the flashing error message **MOVEMENT MONITORING IN <AXIS>** appears.

Analog axes:
An existing offset during a standstill may cause a potential at the analog output without any resulting positioning movement:

- In MP1140.x, enter a threshold from which the movement monitoring should go into effect.

Digital axes:
There is no offset.

- In MP1140.x, enter the speed from which the movement monitoring should go into effect.

For digital axes, in addition to the comparison of actual and nominal values, the calculated position from the pulses of the position encoder are compared with the pulses of the speed encoder:

- Enter in MP332.x the number of signal periods and in MP331.x the path for the number of signal periods (See page 6 – 6).
- Enter the distance per motor revolution in MP1054.x. A formula can also be entered in MP1054.x.
- In MP1144.x, enter a limit value for this position difference. If you are not using a position encoder, you must enter 0 in MP1144.x as the position difference.

If the difference is greater than the input value from MP1144.x, the error message **MOVEMENT MONITORING IN <AXIS> B** appears.

Warning

If you enter the maximum value in MP1140.x or MP1144.x, no movement monitoring is active.
Safe machine operation is not possible without the movement monitoring function.

MP1140.x **Threshold at which the movement monitoring goes into effect**
Input: Analog axes: 0.030 to 10.000 [V]
Digital axes: 0.030 to 10.000 [1000 rpm]
Recommended: 0.030 [1000 rpm]

MP1054.x **Linear distance of one motor revolution**
Input: Analog axes: Nonfunctional
Digital axes: 0 to 100.000 [mm] or [°]

MP1144.x **Motion monitor for position and speed**
Input: Analog axes: Nonfunctional
Digital axes: 0 to 99 999.999 [mm]
0: No monitoring

6.11.4 Standstill Monitoring

Standstill monitoring is effective during operation both with velocity feedforward and with following error, as soon as the axes have reached the positioning window.

If the position difference is greater than the value defined in MP2800.x, the blinking error message **STANDSTILL MONITORING IN <AXIS>** appears. The message also appears if, while moving to a position, an overshoot occurs that is larger than the input value in MP1110.x, or if the axis moves in the opposite direction when beginning a positioning movement:

- In MP1110.x, enter a threshold from which the standstill monitoring should go into effect.

MP1110.x	**Standstill monitoring**
Input:	0.0010 to 30.0000 [mm]

6.11.5 Positioning Window

The positioning window defines the limits within which the control considers a position to have been reached. After the position has been reached, the control begins running the next block. The position controller can correct a disturbance inside this window without activating the "Return to the Contour" function.

- In MP1030.x, define the size of the positioning window.

MP1030.x	**Positioning window**
Input:	0.0001 to 2.0000 [mm]

Axes in position

Once the axes have moved into the positioning window, the corresponding bits are set in W1026. This also applies to the status after the machine control voltage is switched on. Axes that are not used are considered to be in position.

The NC resets the bits as soon as you start a positioning movement or traverse the reference marks.

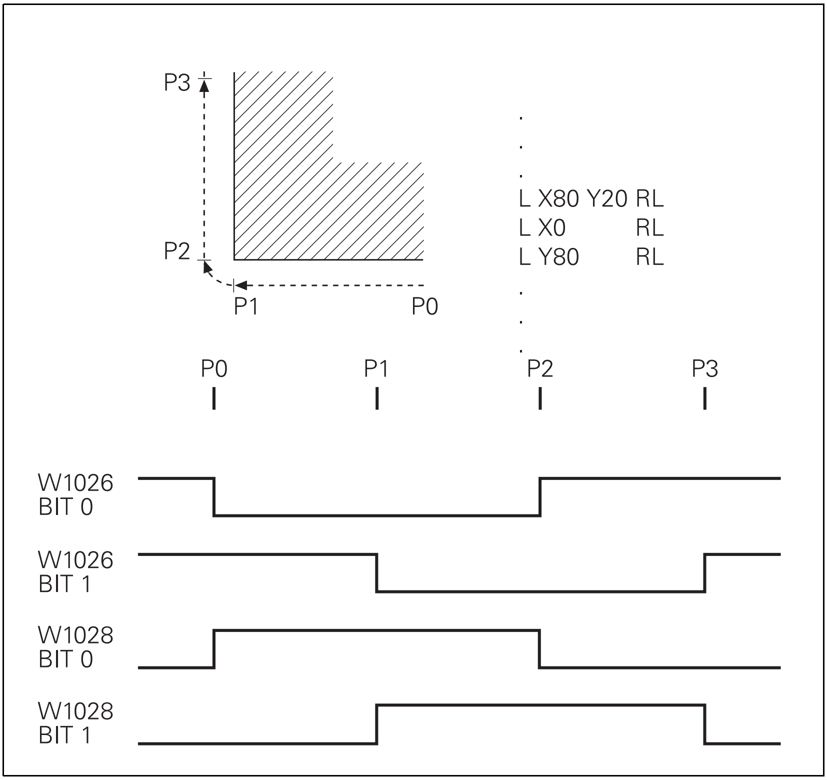
In the ELECTRONIC HANDWHEEL mode of operation the bit for the current handwheel axis is reset.

On contours that can be machined with constant surface speed, W1026 is not set.

		Set	Reset
W1026	**Axes in position** Bits 0 to 8 represent axes 1 to 9 0: Axis not in positioning window 1: Axis in positioning window	NC	NC

Axes in motion During axis movement, the NC sets the corresponding bits in W1028.

		Set	Reset
W1028	**Axes in motion** Bits 0 to 8 represent axes 1 to 9 0: Axis not in motion 1: Axis in motion	NC	NC



6.11.6 Monitoring of the Power Supply Unit

The rectified supply voltage of the power supply unit is monitored. The supply voltage must lie within a defined range.
(400 V +/– 10%). If this is not the case the power supply unit reports an AC fail ($\overline{\text{PF.PS.AC}}$).

At the same time, the dc-link voltage is monitored:

- If approx. 760 Vdc (UV 120, UV 140, UV 150, UR 2xx: approx. 800 V) is exceeded, the NC revokes the pulse release (reset) for the IGBT of the power module. The motors coast out of loop to a stop. No energy is returned to the dc link.
- If the dc-link voltage falls below approx. 385 Vdc (UV 120, UV 140, UV 150. UR 2xx: approx. 410 V), the power supply unit reports a powerfail (signal $\overline{\text{PF.PS.ZK}}$)
- If the dc-link voltage falls below approx. 155 Vdc (UV 120, UV 140, UV 150, UR 2xx, UV 105: approx. 200 V), the control is reset (signal $\overline{\text{RES.PS}}$).
- Below approx. 135 Vdc (UV 120, UV 140, UV 150, UR 2xx, UV 105: approx. 180 V), the power supply unit switches off.

The UV 105 power supply unit reports a powerfail if the dc-link voltage is < approx. 385 V and the supply voltage is < approx. 330 V.

▶ With MP2150, you define which inverter signal is to trigger the **`Powerfail`** on the control.

Inverter signal	Meaning
AC fail ($\overline{\text{PF.PS.AC}}$)	Failure of supply voltage for inverter
Power fail ($\overline{\text{PF.PS.ZK}}$)	dc-link voltage failure

Since the AC fail is reported to the control before the powerfail, the control has more time to react to the subsequent dc-link voltage failure.

Note

Only the following HEIDENHAIN power supply units provide the AC-fail signal:

- UV 120
- UV 140
- UV(R) 150
- UR 2xx

For all other HEIDENHAIN components, the AC-fail signal must not be selected in MP2150.

If a power fail is triggered on the control, all drives are brought to a controlled stop. The PLC outputs are switched off and the control displays the error message **`POWERFAIL.`** The control must be turned off and on again.

MP2150 Powerfail signals on the control
Input: 0: AC fail
1: Power fail and AC fail
2: Neither powerfail nor AC fail
3: Powerfail

Module 9167 Monitoring of dc-link voltage

With this module you can switch the dc-link voltage monitoring for powerfail (U_Z < approx. 385 V or 410 V) on and off.

If you don't call the module during the first PLC run-through, the supply voltage monitoring is automatically started after the first PLC run-through.

Call:

PS	B/W/D/K	<Command code> 0: DC-link voltage monitoring off 1: DC-link voltage monitoring on
CM	9167	
PL	B/W/D	<Error code> 0: Command executed –1: Transferred parameter invalid

Error detection:

Marker	Value	Meaning
M4203	0	DC-link voltage monitoring on or off
	1	Error code in W1022
W1022	2	Transferred parameter invalid

6.11.7 Temperature Monitoring

Temperature of the MC 422

The internal temperature of the MC 422 is continuously monitored. At about 55 °C the temperature warning **TNC temperature warning** appears. If the temperature does not fall below 55 °C, the warning is reactivated after two minutes. Beginning at about 60 °C the error message **TNC temperature too high <temperature> °C** appears and an emergency stop is triggered. If the machine is switched on again and the temperature does not go below 60 °C, the error message is reactivated after about 10 to 20 seconds.

The temperature of the MC 422 can be found with Module 9133.

Module 9133 Temperature of the MC 422

Call:

PS	B/W/D/K	<Code> 0: Internal temperature of the MC 422 1: Temperature of the CPU
CM	9133	
PL	B/W/D	<Temperature in °C>

Error detection:

Marker	Value	Meaning
M4203	0	Internal temperature was read
	1	Error code in W1022
W1022	2	Invalid code

Motor temperature

To measure the motor temperature, a KTY 84 must be connected at pins 13 and 25 of X15 to X20, X80 to X83. The temperature value is ascertained at least once per second. The maximum permissible motor temperature is taken from the motor table.

As soon as the given temperature is exceeded, the blinking error message **MOTOR TEMPERATURE <AXIS> TOO HIGH** appears and the drives are automatically switched off.

Module 9165 Sampling the current motor temperature

Appropriate measures can be taken before the motor reaches the maximum temperature.

Call:

PS	B/W/D/K	<Axis> 0 to 8 and 15 = Axes 1 to 9 and the spindle
CM	9165	
PL	B/W/D	<Temperature> Range: 0 to 255 °C

Error detection:

Marker	Value	Meaning
M4203	0	No error
	1	Control has no current controller

Temperature of the power module's heat sink

At X51 to X60 the temperature warning signal is available at pin 13.

If the permissible temperature of the heat sink on the power module is exceeded, this signal is reset.

Warning

To avoid destroying the power module, the drives must be brought immediately to a standstill after a temperature warning.

Data on maximum permissible temperatures are available from the manufacturer of your power module.

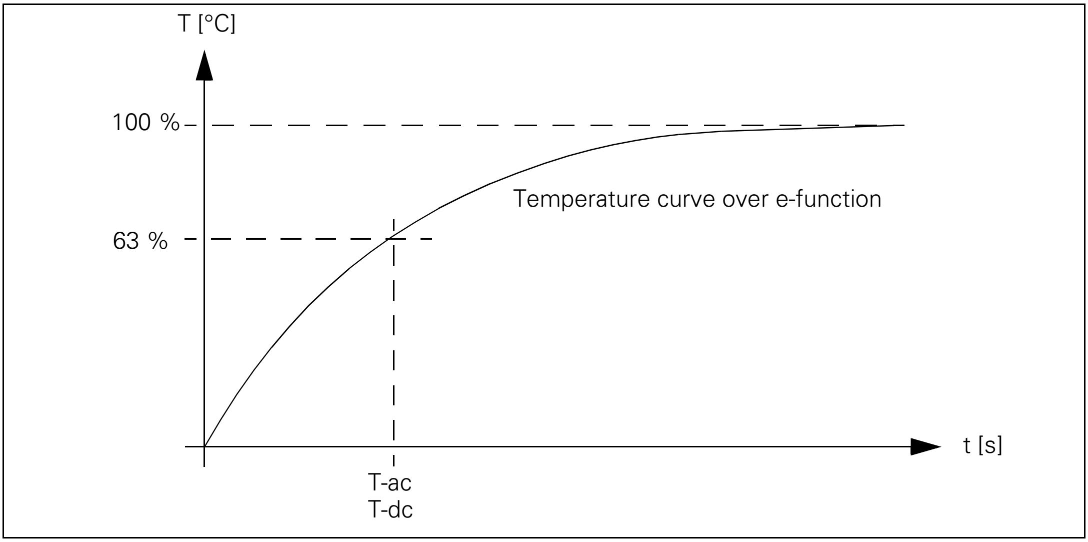
The temperature warning signal is not evaluated in the NC:

- Use Module 9160 or 9066 to interrogate the temperature warning, and take appropriate measures.

6.11.8 I^2t Monitoring

The instantaneous motor current is limited to either the maximum current of the power module, or the maximum motor current, whichever is lower. The values result from the type of power supply unit and type of motor, and are saved in the motor or power-supply-unit table.

In addition, a separate I^2t monitoring is performed for the power module and the motor:
The temperature increase of the motor and power stage is proportional to the square of the current output. Since the heat dissipation can be uneven if the motor is stationary or moving slowly, the monitor distinguishes between two ranges. This is the purpose of the F-ac entry (**`Cutoff frequency for T-ac [Hz]`**) in the motor-and-power-module table. Above this frequency, the T-ac entry (**`Therm. time constant for ac [s]`**) applies, and below it the T-dc entry (**`Therm. time constant for dc [s]`**) applies. The T-ac and T-dc entries identify the point in the temperature curve at which 63% of the maximum temperature is reached. This defines a temperature model of the motor or power stage.



With the aid of this temperature model, a mean current value is permanently calculated. If this calculated mean current value exceeds the rated current (for motors, plus MP2302.x and additionally for power modules MP2304.x), the I^2t monitoring (Module 9160) responds. In this case, you should reduce the machining feed rate in the PLC program. If the calculated mean current value is more than 1.1-fold of the rated current, (for motors, plus MP2302.x) an error message appears; the drives are not switched off.

- In MP2302.x, enter a reference value for I^2t monitoring of the motor. The input value is a factor of the rated current of the motor (1 = rated current of the motor). If you enter zero, the I^2t monitoring for the motor (not for the power supply unit) is switched off.
- In MP2304.x, enter a reference value for I^2t monitoring of the power module. The input value is a factor of the rated current of the power module (1 = rated current of the power module). If you enter zero, the I^2t monitoring for the power module (not for the motor) is switched off.

Note

In the oscilloscope you can display the current value of the I^2t monitoring of the motor and power stage, as well as the current load of the drive.

The I^2t monitoring according to the temperature model above can only be used if entries not equal to 0 are in the **F-DC, T-DC, F-AC** and **T-AC** columns of the motor or power module tables.

If the value 0 is entered in these columns, the following default values are valid:

- Axis drives:
  - F-DC = 0
  - T-DC = 10
  - F-AC = 0
  - T-AC = 10
- Spindle drives:
  - F-DC = 0
  - T-DC = 150
  - F-AC = 0
  - T-AC = 150

In the power module table, all HEIDENHAIN inverters whose names do **not** end in **"...-QAN"** or **"...-QSY"** have entries in these columns.

MP2302.x **Reference value for I^2t monitoring of motor**
Input: 0 to 1000.000 [· rated current of motor]
0: I^2t monitoring of motor switched off
1: Rated current of motor as reference value

MP2304.x **Reference value for I^2t monitoring of the power module**
Input: 0 to 1000.000 [· rated current of power module]
0: I^2t monitoring of power module switched off
1: Rated current of power module as reference value

Module 9160 Status request for temperature monitoring and I^2t monitoring

Call:

```
CM   9160
PL   D      <Temperature monitoring>
            Bit       15     876543210
            Axis:     Sxxxxx987654321
PL   D      <I2t monitoring>
            Bit       15     876543210
            Axis      Sxxxxx987654321
```

Error detection:

Marker	Value	Meaning
M4203	0	No error
	1	Control has no current controller

6.11.9 Read Actual Utilization of Drive Motors

Module 9166 provides the momentary utilization of the given drive motor as a percentage value.

Utilization means:

Speed range	$n_{act} < n_N$	$n_{act} \geq n_N$
Asynchronous motor	$\frac{\lvert M \rvert}{\lvert M_{rated} \rvert}$	$\frac{\lvert P \rvert}{\lvert P_{rated} \rvert}$
Synchronous motor	$\frac{\lvert M \rvert}{\lvert M_{rated} \rvert}$	–

Instead of the drive torque, one uses the effective component I_q of the current, which is proportional to the torque.

I_{qMean} is formed as mean value of the individual current values I_{qx} of the last 20 ms:

$$I_{qMean} = \frac{\sum(I_{q1}..I_{qn})}{n}$$

$$\text{Utilization} = 100\ \% \cdot \frac{I_{qMean}}{I_{qRated}}$$

For asynchronous motors:

$$I_{qRated} = \sqrt{{I_N}^2 - {I_{mag}}^2}$$

I_N: Rated current of motor
I_{mag}: Magnetizing current

For synchronous motors:

I_{qRated} = <Rated current of motor>

Module 9166 Momentary utilization of the drive motor

The evaluation through MP2312.x is already calculated in the utilization of the drive motor.

Call:

```
PS    B/W/D/K   <Axis>
                0 to 8 and 15 = Axes 1 to 9 and the spindle
CM    9166
PL    B/W/D     <Utilization of the drive in %>
```

Error detection:

Marker	**Value**	**Meaning**
M4203	0	No error
	1	Control has no current controller

MP2312.x Reference value for utilization of motors

Input: 0 to 1000.000 [· rated current of motor]
0 or 1: Reference value is rated current of motor

6.11.10 Status of HEIDENHAIN Inverters

Status information of the HEIDENHAIN inverters can be read with Module 9066.

Module 9066 Status of HEIDENHAIN inverter

Call:

PS	B/W/D/K	<Code> 0: HEIDENHAIN inverter
CM	9066	
PL	B/W/D	<Status information> Bit 0: Nonfunctional Bit 1: DC-link voltage too high (ERR.UZ.GR) Bit 2: Heat sink temperature too high (ERR.TEMP) Bit 3: Short-circuit of a motor phase with U_Z (AXISFAULT) Bit 4: DC-link current too high (ERR.IZ.GR) Bit 5: Power supply unit not ready (RDY.PS) Bit 6: Leakage current too high (ERR.ILEAK)

Error detection:

Marker	Value	Meaning
M4203	0	Status has been read
	1	Error code in W1022
W1022	2	Invalid code
	24	Module was called in a spawn job or submit job

The HEIDENHAIN power supply units have several status signals which lead to error messages on the control. MP2195 is used to suppress the error message for each status signal.
HEIDENHAIN does not recommend suppressing the error messages from the power supply units.

MP2195	**Suppress error messages of the HEIDENHAIN supply units**
Format:	%xxxxxxxx 0: Error message is not suppressed 1: Error message is suppressed
Input:	Bit 0: Reserved Bit 1: ERR.UZ.GR signal Bit 2: ERR.TMP signal Bit 3: Reserved Bit 4: ERR.IZ.GR signal Bit 5: RDY.PS signal Bit 6: ERR.ILEAK signal Bit 7: Reserved

6.11.11 Controlling the Motor Brakes

The motor brakes are controlled with the $\overline{\text{BRK}}$ braking signal, which reaches the HEIDENHAIN inverters via the PWM interface (X51 to X62). The corresponding outputs are activated there. See the basic circuit diagrams. Control of the motor brakes via the PWM interface must be deactivated for non-HEIDENHAIN inverters that do not support this function:

- Set bit 0 = 1 in MP2234.x

The motor brakes are opened no later than 50 ms after the speed controller is switched on. For safety reasons, the controller is not switched off until the braking signal has been output:

- Enter in MP2308.x the time (overlap time) after which the controller is to be switched off (after the braking signal has been output).

If the inverter sends the $\overline{\text{RES.PS}}$ reset signal, then the $\overline{\text{BRK}}$ braking signals are output immediately upon switch-off of the controllers, i.e. without any overlap time.

Activated brakes cause a change in the controlled system. The motor with the changed controlled system is controlled during the overlap time. This can lead to oscillations when the controller is switched off. These oscillations are suppressed by the NC software. MP2220 bit 3 can be used to not suppress the vibrations. HEIDENHAIN does not recommend switching off the suppression of the vibrations.

MP2220	**Monitoring functions**
Input:	Bit 3 – Switching off the controller when the motor brakes are activated 0: Suppress vibrations 1: Vibrations are allowed
MP2234.x	**Internal triggering of the motor brakes via the PWM interface**
Format:	%xx
Input:	Bit 0 – 0: Signal is transmitted 1: Signal is not transmitted Bit 1– reserved
MP2308.x	**Time between output of the braking signal $\overline{\text{BRK}}$ and switching off of the controller (overlap time)**
Input:	0.001 to 0.500 [s] 0: 0.200 s

Automatic test of the motor brakes at switch-on

After switching on the drive, but before traversing the reference mark, you can carry out an automated functional test of the motor brake. For the period of one second, a current is output while the brake is applied. The path that the axis has moved is then measured. If the permissible path is exceeded, the error message **`8130 Motor brake defective <axis>`** appears, and the axis remains controlled. The test is carried out simultaneously for all affected axes.

Warning

In case of an error, the axis must be moved to a safe position, and physically supported, if necessary. Only then may the machine be switched off so that the defect can be corrected.

If no motor current flows while testing the motor brakes, the error message **`8140 No current for brake test <axis>`** appears.

- Enter in MP2230.x a factor for the rated current with which the motor brake test is to be carried out. If the test is not to be carried out, or for motors without brakes, enter MP2230.x = 0.
- Enter in MP2232.x the permissible path that the motor is allowed to move against the brake. If the test is not to be carried out, or for motors without brakes, enter MP2232.x = 0.

MP2230.x **Factor for rated current during test of motor brake**

Input: 0.1 to 30.0 [· rated current of motor]
0: No test of motor brakes, or motor without brake
1.3: Recommended input value

MP2232.x **Maximum permissible path during test of motor brakes**

Input: 0 to 10.0000 [mm] or [°]

6.11.12 EMERGENCY STOP monitoring

On the control there is a PLC input (X42/4) and a PLC output (X41/34) with the designation control-is-ready for the EMERGENCY STOP routine.

If a functional error is detected, the iTNC switches the control-is-ready output off. An error messages appears and the PLC program is stopped. Some error messages **cannot** be cleared with the CE key:

- Correct the error and restart the switch-on routine.

If the “control-is-ready signal acknowledgment” input is switched off by a process external to the control, the error message **EXTERNAL EMERGENCY STOP** appears. The NC sets M4177 and M4178. The nominal speed value 0 is output and the drives are switched off. You can clear this error message with CE after switching the machine control voltage back on.

The “control-is-ready signal acknowledgment” input is passed directly onto the NC; it can **not** be manipulated by the PLC (I3).

Resetting the “control-is-ready signal acknowledgment” inputs leads to position monitoring being shut off for the time defined in MP1150.1, and to an actual-to-nominal value transfer. After the time defined in MP1150.1 has expired, position monitoring is again active, for at least the time defined in MP1150.2.

If marker M4580 is set, then instead of the external emergency stop (“control-is-ready signal acknowledgment” input), the control loops of all axes and of the spindle are opened, and an NC stop is performed.

		Set	Reset
M4177	**Erasable error message is displayed**	NC	NC
M4178	**Error message EMERGENCY STOP is displayed**	NC	NC
M4580	**Suppress EMERGENCY STOP, open all position control loops, NC stop**	PLC	PLC

Testing an internal EMERGENCY STOP

For test purposes, an internal EMERGENCY STOP can be simulated in order to inspect the correct wiring of the machine. The control-is-ready output is reset. The NC and PLC are no longer operable.

Danger

Hanging axes must be supported before the test in order to prevent damage to the machine in case of error.

- Enter the code number **FAILTEST** under MOD.
- Acknowledge the message window with the YES soft key in order to carry out the test.

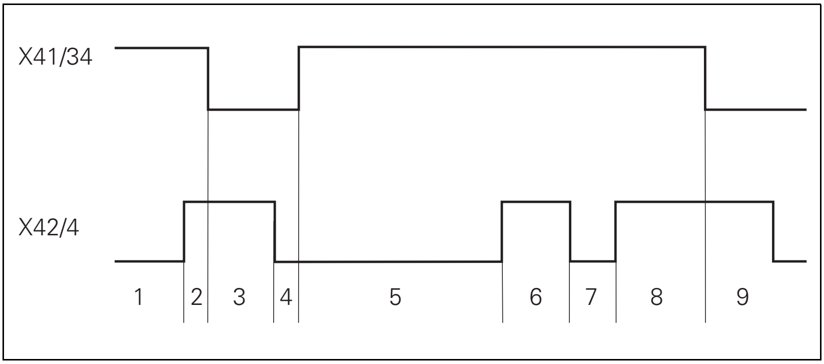
Connection diagram

In the event of an error, the control-is-ready output must trigger an emergency stop. The control therefore checks this output every time that line power is switched on.

Note

The circuitry recommended by HEIDENHAIN is illustrated in the Basic Circuit Diagram.

Ensure that the control-is-ready acknowledgment occurs within 1 second.



Step	Function	Screen display
1	Waiting for machine control voltage	**RELAY EXTERNAL DC VOLTAGE MISSING**
2	Recognition of the machine control voltage on X42/4 and switch-off of the control-is-ready signal on X41/34 by host computer (t < 66 ms)	
3	Maximum time within which the control-is-ready acknowledgment on X42/4 must go to zero (t < 1 s)	If exceeded **EMERGENCY STOP DEFECTIVE**
4	Recognition of the acknowledgment and setting of X41/34 (t < 20 ms)	
5	Waiting for machine control voltage	**RELAY EXTERNAL DC VOLTAGE MISSING**
6	Normal control operation. Control-is-ready output and acknowledgment are high.	
7	Control voltage is switched off externally.	**EMERGENCY STOP**
8	After switching on again, the machine control voltage can be switched off, and then the control operates normally.	
9	After detecting a fault, the control switches off the control-is-ready output (X41/34).	Blinking error message

6.12 Spindle

Two spindles can be controlled alternately. See page 6 – 221.
The main spindle/spindles are controlled with the PLC.

The programmed speed can be output as

- Code via PLC outputs
- Analog nominal speed command signal for an analog spindle
- Digital nominal speed value for a digital spindle

The spindle functions are of varying priorities. If several functions are output at the same time, the function with the highest priority is run, and the rest are deleted. The following spindle function priorities are valid:
Highest: Spindle orientation
Second: Spindle jog
Third: M3/M4
Fourth: M5

- Specify in MP3010 the speed output for the spindle.

MP3010 **Output of speed, gear range**
Input:
0: No output of spindle speed
1: Speed code, if the speed changes
2: Speed code at every TOOL CALL
3: Nominal speed value always, G code if the gear shifts
4: Nominal speed value always, G code at every TOOL CALL
5: Nominal speed value always, no G code
6: Same as 3, but with servo-controlled spindle for oriented spindle stop
7: Same as 4, but with servo-controlled spindle for oriented spindle stop
8: Same as 5, but with servo-controlled spindle for oriented spindle stop

6.12.1 Position Encoder of the Spindle

Analog and digital spindles can be driven in a closed control loop. In this case the spindle needs its own position encoder:

- Define the position encoder input in MP111.x.
  - If you have a digital spindle and would like to use the speed encoder also as a position encoder, then you must set MP111.x = 0.
- Enter in MP3142 the line count of the rotary encoder to be used. 1-V_{PP} signals undergo 1024-fold subdivision.
- Enter in MP3142 how the position encoder is mounted on the spindle. Due to the higher required accuracy, the position encoder must be mounted directly on the spindle: MP3143 = 0.

If design considerations make this impossible:

- Define the encoder-to-spindle transmission ratio in MP3450.x and MP3451.x for each gear stage.

In this case there will be several reference pulses per revolution. For example, with a transmission of 4:1 (motor to spindle), you will receive four reference pulses (every 90°) per spindle revolution.

- Evaluate the reference mark with Module 9220. See "Renewed traversing of the reference marks" on page 6 – 107.

If MP3143 = 2, then the reference pulse release for the spindle position encoder is set with X30, pin 1. Ensure that the same reference signal is always evaluated. The signal must be available for at least as long as the position controller cycle time + 2 ms.

If MP3143 = 1 or 3, then X30 pin 1 is evaluated as the reference signal. The reference mark of the position encoder is not evaluated. In this case the reference signal **must** be evaluated with Module 9220 (See page 6 – 107).

Warning

Due to its low accuracy, this solution is not recommended.

MP111	**Position encoder input for the spindles**
Input:	0: No position encoder input 1 to 6: Position encoder inputs X1 to X6 35 to 38: Position encoder inputs X35 to X38
MP111.0	Position encoder input for the first spindle
MP111.1	Position encoder input for the second spindle
MP3142	**Line count of the spindle position encoder**
Input:	100 to 9999 [lines]
MP3143	**Mounting configuration of the spindle position encoder**
Input:	0: Position encoder immediately on the first spindle 1: Position encoder via transmission (ratio in MP3450.x and MP3451.x); X30 pin 1: reference pulse 2: Position encoder via transmission (ratio in MP3450 and MP3451); X30 pin 1: reference pulse release 3: Same as input value 1, except that the second reference pulse is evaluated.
MP3450.0-7	**Number of spindle position-encoder revolutions for gear ranges 1 to 8**
Input:	0 to 65 535 0: No transmission
MP3451.0-7	**Number of spindle position-encoder revolutions for gear ranges 1 to 8**
Input:	0 to 65 535 0: No transmission

Module 9042 Reading the spindle coordinates (format 0.001°)

The following coordinate values are saved in five successive double words beginning with the specified target address:

- Actual value
- Nominal value
- Actual value in reference system
- Following error (servo lag)
- Distance to go

The values for actual, nominal, and reference value are standardized at 0° to +360.000°.
The values for servo lag and distance-to-go are displayed between –2879.912° and +2879.912°. Format: 0.001°.

If MP3010 < 6 (no closed-loop spindle), then all coordinates are read as zero.

During operation under open-loop control (M03 / M04 active or M05 and open position control loop), the nominal value is considered to be the actual value . The following error and distance to go are considered to be zero.

Call:

```
PS      B/W/D/K   <Target address Cxxxx>
CM      9042
```

Error detection:

Marker	Value	Meaning
M4203	0	Actual speed value was read
	1	Target address is too large or is not a double-word address

Module 9044 Reading the spindle coordinates (format 0.0001°)

Call:

SEE MODULE 9042.

6.12.2 Speed Encoder of the Spindle

Digital speed control requires a shaft speed encoder:

▶ Define the speed encoder input in MP113.x.

The iTNC 530 monitors the reference mark of the speed encoder. The monitor checks whether the line count for one revolution from reference mark to reference mark is equal to the line-count entry in the motor table.
If differences occur, the DSP error message **C3A0 Incorrect reference position S** appears. If this happens, check the speed encoder, encoder cable, and whether you have selected the correct motor.

With a gear wheel encoder, even if it is properly installed, monitoring can result in this error message due to its inherent inaccuracy:

▶ In this case, switch the monitoring off with MP2220 bit 0 = 1.

The iTNC 530 monitors the direction of rotation. If the nominal value of current exceeds the limit value for a certain time, the DSP error message **C380 Motor <spindle 1/2, axis> not controllable** appears.

At lower speeds, high-frequency spindles only have a low amount of torque. If such a spindle is having its speeds controlled, the tool changer may slightly twist the spindle, causing the limit of current to be exceeded. This leads to the above error message:

▶ In this case, switch the monitoring off with MP2221 bit 1 = 1.

Warning

For axes, monitoring of the rotational direction (MP2220 Bit1) must **not** be deactivated. An error (e.g. one motor phase interchanged with another or incorrect entry in the **DIR** column of the motor table) might cause uncontrolled acceleration of the motor in one direction if the monitoring function for the rotational direction is deactivated.
This also applies to spindles. For spindles, however, an incorrect acceleration in one direction is less dangerous than for axes.

As of NC software 340 420-06, monitoring of the direction of rotation (MP2220 bit 1) for synchronous motors (entry **SM** in the column **TYPE** in the motor table) cannot be switched off.

MP113	**Speed encoder for the spindle/spindles**
Input:	0: No speed encoder 15 to 20: Speed encoder inputs X15 to X20 80 to 85: Speed encoder inputs X80 to X85
MP113.0	Speed encoder input for the first spindle
MP113.1	Speed encoder input for the second spindle

MP2220.x	**Monitoring functions**
Input:	Bit 0 – Monitoring the reference mark 0: Monitoring active 1: Monitoring inactive Bit 1 – Monitoring the rotational direction 0: Monitoring active 1: Monitoring inactive

6.12.3 Analog and Digital Closed-Loop Spindle Control

For both analog and digital output of the nominal speed command you can program speeds from 0 to 99 999.999 rpm.

The maximum controllable spindle speed is $\frac{80\,000}{\text{No. of pole pairs}}$.

If the load increases, the spindle speed is corrected until the maximum current is attained. If the load continues to increase in spite of the maximum current, the spindle speed is reduced. For the maximum current, the value from either the motor table or the power-module table of the drive (whichever is lower) applies.

If in MP3010 you have selected the output of the nominal speed value, M4003 is set. The programmed speed is saved in D356, the nominal speed value in W320 and the actual speed value in W322. In addition, the nominal speed value is saved in D364 and the actual speed value in D368, since speeds above 32 767 rpm cannot be represented in words W320 and W322.
With D604 you can limit the possible spindle speed through the PLC. To ensure compatibility, D604 is preassigned with 99 999 999 after control switch-on or after an interruption in the PLC scan.

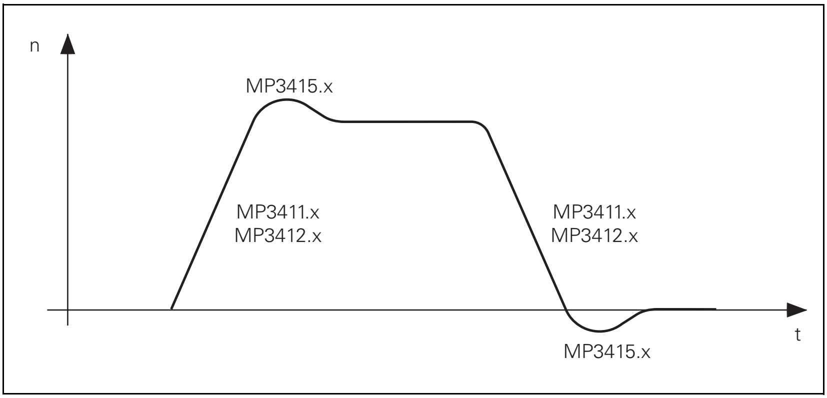
Analog spindles:
The nominal speed value of the motor is output as an analog dc voltage of ±10 V at connection X8 or X9.

Digital spindles:
The nominal speed value is transferred to the internal speed controller.

		Set	Reset
M4003	**Nominal speed value output analog or digital (MP3010 = 3 to 8)**	NC	NC
D356	**Programmed speed [0.001 rpm]**	NC	NC
D364	**Nominal speed value [rpm]**	NC	NC
W320	**Nominal speed value [rpm]**	NC	NC
D368	**Actual speed value [rpm]**	NC	NC
W322	**Actual speed value [rpm]**	NC	NC
D604	**Maximum possible spindle speed**	PLC	NC/PLC

Nominal speed value

- In MP3411.x, define the ramp gradient for the nominal speed value at M03 and M04 for each gear range.
- With MP3412.0, specify a multiplication factor for MP3411.x, for
  - M05 (MP3412.0)
  - SPINDLE ORIENTATION (MP3412.1)
  - TAPPING (with floating tap holder) (MP3412.2)
  - RIGID TAPPING (without floating tap holder) (MP3412.3)
    The same factor applies for all gear ranges.
- Set MP3411 for M03, M04 and M05 such that the motor accelerates and brakes within the current limit.
- With MP3415, define the overshoot behavior for every operating mode when the spindle is switched on with M4011. Set MP3415.0 so that only one overshoot is visible.



If the nominal speed value is in the acceleration or deceleration ramp, then M4001 is reset. This also applies if the speed is changed with the override potentiometer.

If the nominal speed value is output as zero, M4002 is set.

MP3411.0-7	**Ramp gradient of the spindle with M03 and M04 for gear ranges 1 to 8**
Input:	Analog axes: 0 to 1.999 [V/ms] Digital axes: 0 to 1.999 [1000 rpm/ms]

MP3415	**Overshoot behavior of the spindle with M03, M04 and M05**
Input:	0 to 1000 [ms]
MP3415.0	With M03, M04 and M05
MP3415.1	For spindle orientation
MP3415.2	For tapping
MP3415.3	For tapping without floating tap holder

MP3412	**Multiplication factor for MP3411.x**
Input:	0 to 1.999
MP3412.0	With M05
MP3412.1	With spindle orientation
MP3412.2	For tapping with floating tap holder
MP3412.3	For tapping without floating tap holder

		Set	Reset
M4001	**Nominal speed command signal of the spindle not in the ramp**	NC	NC
M4002	**Nominal speed value = 0**	NC	NC

Direction of spindle rotation

- With MP3130, define the polarity of the nominal speed value
- In MP3140, enter the counting direction of the position encoder signals.

As soon as you set M4005 for M03, or M4006 for M04, the nominal speed value is output. With M4007 for M05, the nominal speed value zero is output (spindle stop).

M4005 to M4007 also controls the miscellaneous functions in the status window.

If more than one marker is set at the same time, the error message `PLC: M4005, M4006, M4007 INCORRECT` appears.

With M4014 you can reverse the direction of rotation, in order to adjust the transmission for horizontal or vertical spindles, for example. The polarity of the nominal spindle speed is inverted.

M4019 reverses the counting direction of the spindle.

MP3130 **Polarity of the nominal spindle speed**
Input: 0: M03 positive, M04 negative
1: M03 negative, M04 positive
2: M03 and M04 positive
4: M03 and M04 negative

MP3140 **Counting direction of spindle position encoder output signals**
Input: 0: Positive counting direction with M03
1: Negative counting direction with M03

		Set	Reset
M4005	**Status display and nominal speed value output for M03**	PLC	PLC
M4006	**Status display and nominal speed value output for M04**	PLC	PLC
M4007	**Status display M05 and spindle stop**	PLC	PLC
M4014	**Reverse the direction of spindle rotation**	PLC	PLC
M4019	**Reversing the counting direction of the position encoder on the spindle**	PLC	PLC

Disable speed output for spindle

With M4008 you can block the speed output for the spindle. At the same time, M03, M04 or M05 are highlighted. The nominal speed value is zero.

		Set	Reset
M4008	**Disable speed output for spindle**	PLC	PLC

Gear ranges

You can define up to eight gear ranges:

- In MP3510.x, enter for each gear range the rated speed for "S-override 100%."
  Enter the value zero for unnecessary gear ranges.
- In MP3210.x, enter for every gear range the S analog voltage or motor revolutions at rated speed.
- In MP3240.1, define the minimum nominal speed value for the motor.
- In MP3120, define whether zero is permitted as a programmed speed.

If an impermissible speed is programmed, M4004 is set and the error message `WRONG RPM` is displayed.

Note

The gear range from W256 is output when the spindle speed is 0.

MP3510.0-7 Rated speed for the gear ranges 1 to 8
Input: 0 to 99 999.999 [rpm]

MP3210.0-7 Analog nominal spindle voltage at rated speed for the gear ranges 1 to 8
Input: 0 to 100.000 [V]

MP3210.0-7 Digital spindle motor revolutions at rated speed for the gear ranges 1 to 8
Input: 0 to 100.000 [1000 rpm]

MP3240.1 Analog spindle: Minimum nominal value voltage
Input: 0 to 9.999 [V]

MP3240.1 Digital spindle: Minimum motor speed
Input: 0 to 9.999 [1000 rpm]

MP3120 Zero speed permitted
Input: 0: S = 0 permitted
1: S = 0 not allowed

		Set	Reset
M4004	**Impermissible speed was programmed**	NC	NC

Gear shifting

You control the gear shifting through PLC outputs. The NC enters the current gear range according to the programmed speed in W256. The gear range is calculated with MP3510.x. The output of the gear range is defined in MP3010. MP3030 bit 1 determines if the speed should be reduced to 0 when shifting between gears.

When the gear range is changed, the NC uses the G strobe (M4070). As soon as you confirm the gear shift with M4090, the program resumes and the G strobe (M4070) is reset by the NC.
If a TOOL CALL block is followed by the output of a T strobe and G strobe, then M4547 is set by the output of the T strobe and reset by output of the G strobe. If there is no output of either the T or G strobe, M4547 is not set.

In the PLC program you can change the programmed speed and the gear range that is calculated by the NC. This may be necessary, for example, for horizontal/vertical spindles. The programmed speed is saved by the NC in D356 and D756:

- Enter a speed in D756 and a gear range in W256. The speed must lie within the speed range of the gear.
- With M4134, activate your entries in D756 and W256.
- After the NC has reset M4134, change the gear and report with M4090 that the gear shift has been completed.

A changing nominal speed value can be output to shift gears by alternately setting and resetting M4009 and M4010. This can be realized by interrogating the timers in the PLC program. This function also works if you have used M4008 to disable the speed output for the spindle:

- In MP3240.2, define the nominal speed value that is output with M4009/M4010 to the spindle motor.

MP3030	**Behavior of the spindle**
Input:	Bit 1– Zero spindle speed when shifting to another gear range 0: Reduce speed to 0 1: Do not reduce speed to 0
MP3240.2	**Analog spindle: Spindle jog voltage for gear shifting (M4009/M4010)**
Input:	0 to 9.999 [V]
MP3240.2	**Digital spindle: Motor speed for gear shifting (M4009/M4010)**
Input:	0 to 9.999 [1000 rpm]

		Set	Reset
W256	**Gear code**	NC/PLC	NC/PLC
D356	**Programmed speed [0.001 rpm]**	NC	NC
D756	**Programmed speed or speed from PLC [0.001 rpm]**	NC/PLC	NC/PLC
M4009	**Counterclockwise spindle rotation (for gear change)**	PLC	PLC
M4010	**Clockwise spindle rotation (for gear change)**	PLC	PLC
M4070	**Strobe signal for gear code**	NC	NC
M4090	**Acknowledgment of “gear change completed”**	PLC	PLC
M4134	**Activation of a gear range and speed through the PLC**	PLC	NC
M4547	**T and G strobes with TOOL CALL**	NC	NC

Spindle override

You can change the spindle speed within certain limits with the spindle override potentiometer.

- Define the limits in MP3310.x.
- In MP3515.x, enter for every gear range a maximum attainable speed which must not be exceeded with the spindle override.

The percentage adjusted with the spindle override is entered by the NC in W492 and W764. You can change the percentage through the PLC:

- Enter the desired percentage in W764.
  As soon as a new value is entered here, it is assumed by the NC.

The spindle override functions either in 1% steps or according to a nonlinear characteristic curve:

- With MP7620, bit 3, select the mode of the override.

Value range in W492 and W764:

- 1% steps: 1 to 150
- Nonlinear characteristic curve: 0 to 15 000
  In the lowest range, 0.01% steps are available. Beginning with a value of 2.5%, the step is 0.75%

MP3310.0-1	**Limit for spindle override**
Input:	0 to 150 [%]
MP3310.0	Upper limit
MP3310.1	Lower limit

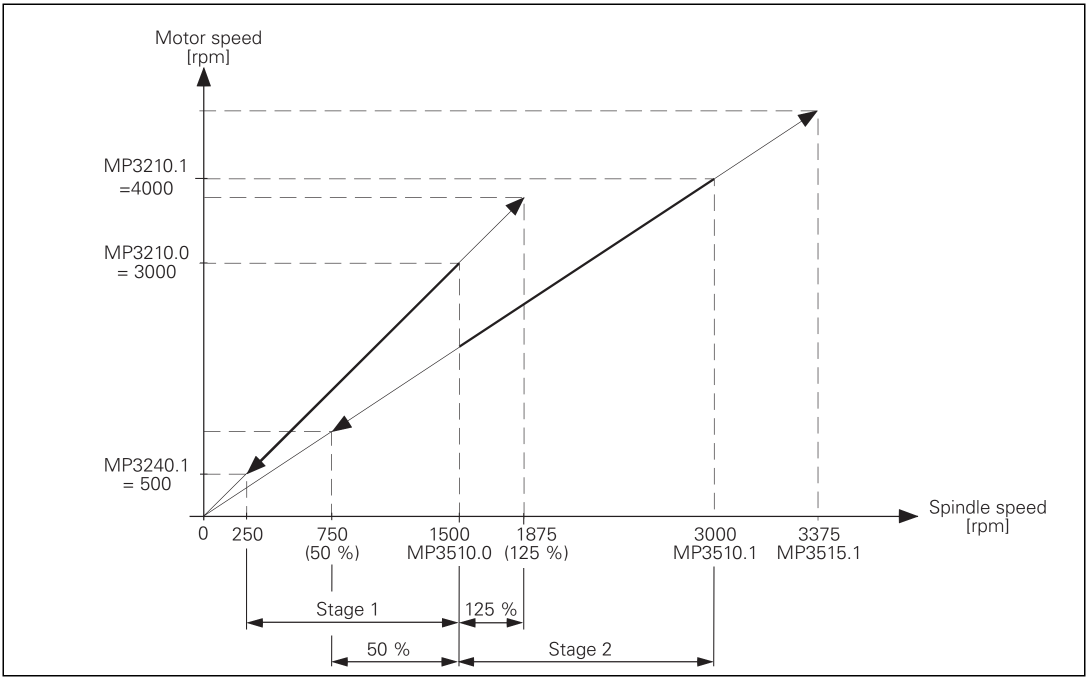
MP3515.0-7	**Maximum spindle speed for gear ranges 1 to 8**
Input:	0 to 99 999.999 [rpm]

MP7620	**Feed-rate override and spindle speed override**
Input:	%xxxxxxx Bit 3 – Feed rate override and spindle speed override in 1% increments or according to a nonlinear characteristic curve: 0: 1% steps 1: Nonlinear characteristic curve

		Set	Reset
W492	**Percentage for spindle override (NC to PLC)**	NC	NC
W764	**Percentage for spindle override (PLC to NC)**	NC/PLC	NC/PLC

Example: Two gear ranges for a digital spindle

- Gear range I: Spindle 1500 rpm with motor 3000 rpm (MP3210.0 = 3000; MP3510.0 = 1500)
- Gear range II: Spindle 3000 rpm with motor 4000 rpm (MP3210.1 = 4000; MP3510.1 = 3000)
- Upper limit for spindle override : 125% (MP3310.0 = 125)
- Lower limit for spindle override: 50% (MP3310.1 = 50)
- Maximum possible output speed for gear range II: 3375 rpm (MP3515.1 = 3375)
- Minimum motor speed: 500 rpm (MP3240.1 = 500)



6.12.4 Coded Output of Spindle Speed

If you have selected speed-code output in MP3010 (entry 1 or 2), an S code is entered in W258. You must output the speed code to the spindle drive through PLC outputs.

If the speed code is changed, the NC sets the S strobe (M4071). If you acknowledge the S code with M4091, the NC program is continued and the S strobe (M4071) is reset by the NC.

If required, the programmed spindle speed is rounded off to the next standard value by the NC and given in S code as per ISO 6983 (see S-code table). Speeds of 0 to 9000 rpm are possible:

- Specify in MP3020 the speed range and the speed increment. The S code for the minimum speed is saved in W1008.

Example:
Minimum speed = 1 rpm (S code 20)
Maximum speed = 1000 rpm (S code 80)
Speed increment = 2:

MP3020 = 20802
W1008 = 20

MP3020	**Speed range for S code output**
Format:	xxyyz xx: S code for minimum speed yy: S code for maximum speed z: Speed increment
Input:	0 to 99 999

		Set	Reset
W258	**S code**	NC	NC
M4071	**Strobe signal for S code**	NC	NC
M4091	**Acknowledgment of S code**	PLC	PLC
W1008	**S code for minimum speed**	NC	NC

S code table

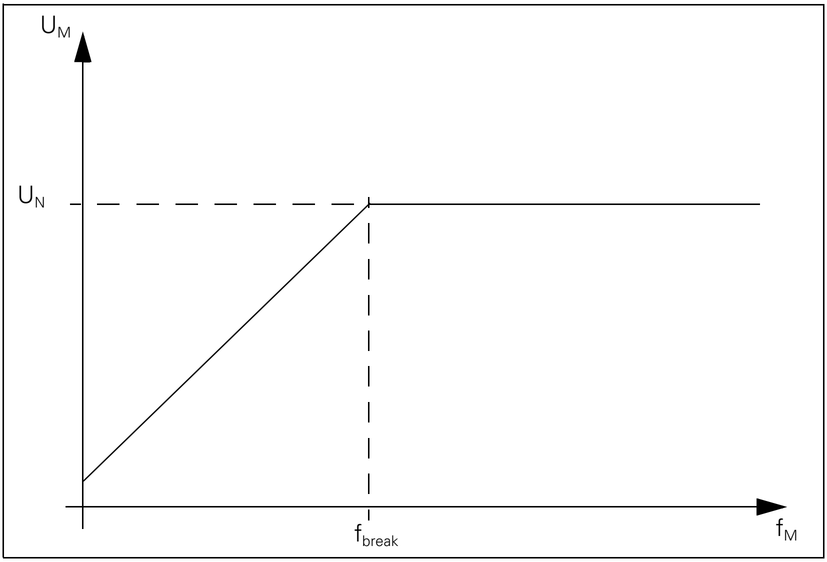
S code	rpm
S 00	0
S 01	0.112
S 02	0.125
S 03	0.14
S 04	0.16
S 05	0.18
S 06	0.2
S 07	0.224
S 08	0.25
S 09	0.28
S 10	0.315
S 11	0.355
S 12	0.4
S 13	0.45
S 14	0.5
S 15	0.56
S 16	0.63
S 17	0.71
S 18	0.8
S 19	0.9
S 20	1
S 21	1.12
S 22	1.25
S 23	1.4
S 24	1.6
S 25	1.8
S 26	2
S 27	2.24
S 28	2.5
S 29	2.8
S 30	3.15
S 31	3.55
S 32	4
S 33	4.5
S 34	5
S 35	5.6
S 36	6.3
S 37	7.1
S 38	8
S 39	9
S 40	10

S code	rpm
S 41	11.2
S 42	12.5
S 43	14
S 44	16
S 45	18
S 46	20
S 47	22.4
S 48	25
S 49	28
S 50	31.5
S 51	35.5
S 52	40
S 53	45
S 54	50
S 55	56
S 56	63
S 57	71
S 58	80
S 59	90
S 60	100
S 61	112
S 62	125
S 63	140
S 64	160
S 65	180
S 66	200
S 67	224
S 68	250
S 69	280
S 70	315
S 71	355
S 72	400
S 73	450
S 74	500
S 75	560
S 76	630
S 77	710
S 78	800
S 79	900
S 80	1000
S 81	1120

S code	rpm
S 83	1400
S 84	1600
S 85	1800
S 86	2000
S 87	2240
S 88	2500
S 89	2800
S 90	3150
S 91	3550
S 92	4000
S 93	4500
S 94	5000
S 95	5600
S 96	6300
S 97	7100
S 98	8000
S 99	9000

6.12.5 Volts-per-Hertz Control Mode

In volts-per-hertz control mode (U/f control mode), the motor is speed-controlled in an open loop. The motor voltage increases in proportion to frequency up to the break (= threshold rpm for field weakening). Then the motor voltage remains constant (= rated voltage of motor); only the frequency continues to increase.
If the spindle reaches the maximum current due to excessive load, the error message **C380 Motor <Spindle 1/2> not controllable** appears. For the maximum current, the value from either the motor table or the power-module table of the drive (whichever is lower) applies.



The maximum speed in the volts-per-hertz control mode corresponds to the maximum speed in closed loop operation.

To drive a motor with a U/f component:

- In the motor table, enter for your motor in the column **Motor model** (TYPE) UASM, in the column **Encoder line count** (STR.) the value 0, in the column **Type of encoder** (SYS) the value 0 and in the column **Maximum temperature** [°C] T-MAX the value 255.
- The machine parameters for current controller (MP24xx.y) and speed controller (MP25xx.y, MP 26xx.y) are nonfunctional.
- The acceleration and breaking ramp (MP341x) must be set so that the maximum current is not exceeded.

Since during volts-per-hertz (U/f) control mode no speed encoder is used, W322 = 0 (actual speed value) supplies the value 0.

- Module 9164 can determine the actual speed value while the spindle is running, but not during the acceleration and braking phases.

Note

The oscilloscope shows the actual current instead of the nominal current (I NOML), since there is no nominal current with U/f components.

6.12.6 Oriented spindle stop

For spindle orientation the spindle must be in a closed control loop:

- Mount a position encoder for the spindle.
- With MP3010 (input value 6 to 8), specify whether the control provides for spindle orientation.

In the NC's touch probe cycles and rigid tapping cycle, the NC orients the spindle directly. In these cases, the NC sets M4017. You must reset M4012 in the PLC.

To orient the spindle to a specific angle in an NC program, use FN17: SYSWRITE ID990 NR8. The conditions above must be followed. The NC program resumes after the spindle is in position (M4000).
You can ascertain the current spindle angle with FN18: SYSWRITE ID990 NR8.

If the spindle orientation is started with an M function (e.g. M19), you must activate the oriented spindle stop in the PLC.
In MP7442, enter the number of the M function (e.g., 19) which will trigger the oriented spindle stop during the machining cycles. If MP7442 = 0 (no oriented spindle stop), the error message **`ORIENTATION not permitted`** appears when a cycle which uses oriented spindle stop is called.

The spindle orientation runs asynchronously to the NC positioning commands. You may only acknowledge the orientation once the spindle is in position (M4000).

The NC starts orienting the spindle only if the drive is switched on with Module 9161.

There are three ways to orient the spindle in the PLC:

- Module 9171
- Marker M4130
- Via initiator with marker M4011

MP7442	**Number of the M function for spindle orientation in the cycles**
Input:	1 to 999: Number of the M function 0: No oriented spindle stop –1: Oriented spindle stop by the NC

Oriented spindle stop with Module 9171

The spindle speed is reduced in open-loop control along the ramp from MP3412.1 to the speed for spindle orientation (MP3520.1). As soon as this speed is reached, the control loop closes. The spindle is oriented in feedback control along the ramp from MP3412.1 to the nominal position. As long as the spindle moves in a closed loop, M4017 remains set:

- In MP3440.x, assign each gear range a k_v factor for adjusting the gear ranges.
- In MP3415.1, define the overshoot behavior of the first spindle during spindle orientation.
- Define the positioning window in MP3420. As soon as the spindle is in the positioning window, M4000 is set.

If the spindle should not remain in the position control loop after it reaches the nominal position, then you must set M4012. After the marker is set, the spindle is not feedback controlled any longer.

If M4012 always remains set, the control loop opens after every oriented spindle stop as soon as the positioning window is reached.

You can compensate a maladjustment resulting from mounting the rotary encoder:

- In MP3430, enter the offset between the nominal and actual position of the reference mark. The offset is then compensated during orientation.

After the spindle is switched on, the NC evaluates the reference mark, even if the position control loop is not closed. M4018 is set until the reference mark is evaluated. For special applications you can evaluate the reference mark again by setting M4015. The NC resets M4015 when the reference mark is evaluated.

- With MP7291, select the display mode for the spindle position. If M03 and M04 are not active, the display returns to zero every 360 degrees (modulo function).

MP3412.1 **Multiplier for MP3411 during spindle orientation**
Input: 0 to 1.999

MP3415.1 **Spindle overshoot behavior during orientation**
Input: 0 to 1000 [ms]

MP3420 **Spindle positioning window**
Input: 0 to 360.0000 [°]

MP3430 **Deviation of the reference mark from the desired position (spindle preset)**
Input: 0 to 360 [°]

MP3440.0-7 **k_v factor for spindle orientation for gear ranges 1 to 8**
Input: 0.1 to 10 [(1000°/ min) /°]

MP3520.1 **Spindle speed for oriented stop**
Input: 0 to 99 999.999 [rpm]

		Set	Reset
M4000	**Spindle in position**	NC	NC
M4012	**Opening the spindle control loop**	PLC	PLC
M4015	**Renewed evaluation of the spindle reference mark**	PLC	NC
M4017	**Spindle moving in feedback control**	NC	NC
M4018	**Reference mark for spindle not yet traversed**	NC	NC

With Module 9171 you can specify the speed, nominal position and direction of rotation for spindle orientation.

M4130 is set as long as the positioning movement lasts.

Module 9171 Oriented spindle stop

The module functions only in the cyclic PLC program. If you call the module while the spindle is rotating, the transferred direction will be ignored. The spindle will be oriented in the direction of spindle rotation.

If the values 2 to 4 are transferred as direction of rotation, the spindle will be oriented to the angle last defined in CYCL DEF 13. The transferred angle is added to the value from CYCL DEF 13.

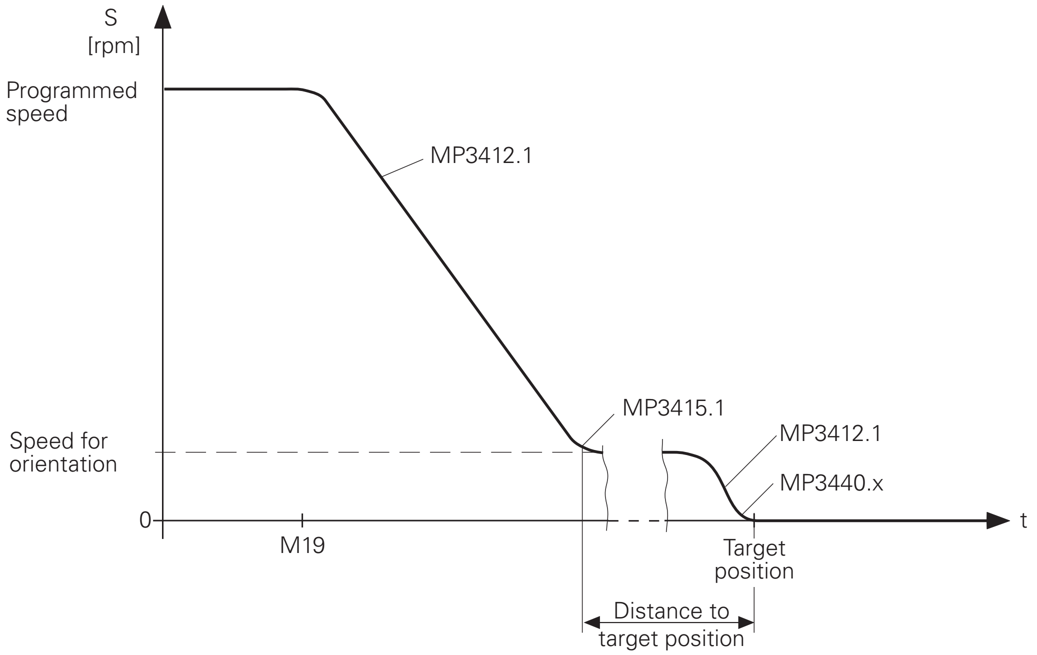
Call:

PS	B/W/D/K	<Angle [1/10 000 °]> or additional preset if there is a value from CYCL DEF 13
PS	B/W/D/K	<Speed [1/1000 rpm]> 0: MP3520.1 is assumed
PS	B/W/D/K	<Direction of rotation> –1: Negative direction (M04) 0: Direction of the shortest path 1: Positive direction (M03) 2: Same as -1 but angle from CYCL DEF 13 3: Same as 0 but angle from CYCL DEF 13 4: Same as +1 but angle from CYCL DEF 13
CM	9171	

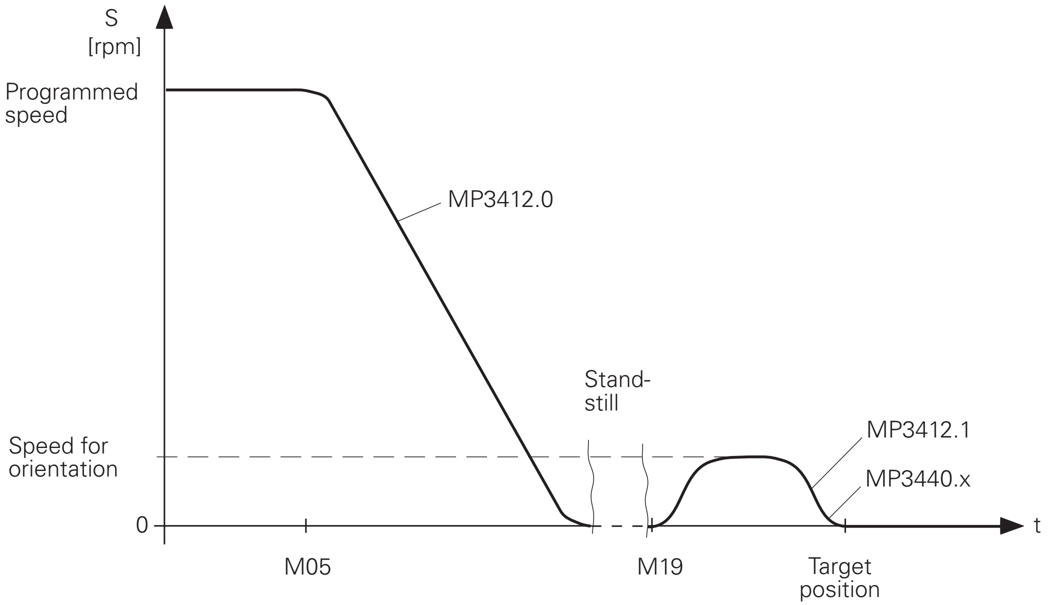
Error detection:

Marker	Value	Meaning
M4203	0	Spindle is brought to an oriented stop
	1	Error code in W1022
W1022	1	Incorrect value for direction of rotation or rotational angle
	2	Incorrect speed
	19	No feedback-controlled spindle
	24	The module was called in a spawn job or submit job
	27	A spindle orientation is already running

Orienting a moving spindle



Orienting a stationary spindle



Oriented spindle stop with M4130

You can start the spindle orientation with M4130. The nominal position is taken from D592 and the speed from MP3520.1. The nominal position is with respect to the reference point.

For example, the nominal position can be transferred with MP4210.x or taken from the oriented spindle stop cycle (CYCL DEF 13). If the value is taken from the cycle, you must set the MSB of D592 to 1 and the other bits to 0. M4016 is set during execution of Cycle 13.

From a standstill, the spindle is oriented on the shortest path. Prerequisite: At the start, the distance between the nominal and actual position must not be greater than the positioning window (MP3420). If the distance is greater than the positioning window, the spindle is positioned according to M4013 with M03 or M04.

		Set	Reset
D592	**Nominal position for spindle orientation**	PLC	PLC
M4013	**Direction for spindle orientation from a standstill (M03 = 0; M04 = 1)**	PLC	PLC
M4016	**Cycle 13 is executed**	NC	PLC
M4130	**Activation of spindle orientation, or spindle orientation has been started with Module 9171**	NC/PLC	NC

MP4210.0-47 Setting a number in the PLC (D768 to D956)
Input: –99 999.9999 to +99 999.9999

Oriented spindle stop via proximity switch with M4011

The spindle can be oriented through a proximity switch:

- Set M4011.

Then the spindle is moved in the direction from M4013 and at the speed from MP3520.0. The spindle is stopped as soon as you reset M4011. The current positioning value is shown in the status window.

MP3520.0 Speed activation through marker M4011
Input: 0 to 99 999.999 [rpm]

		Set	Reset
M4011	**Activate rotational speed MP3520.0 and direction of rotation from M4013**	PLC	PLC

Offset compensation (only analog spindles)

After spindle orientation the offset is compensated automatically. In order to give the spindle enough time to settle to a stop, the offset compensation is delayed until the spindle has been in position for at least two seconds. The offset is then compensated in intervals of 0.152 mV per second. The spindle turns slowly due to the offset voltage.

6.12.7 Tapping with Floating Tap Holder and Nominal Speed Output

For tapping with floating tap holder, the position control loop is open. M4030 is set during the tapping cycle. After the spindle is switched on with M03, this is acknowledged with M4092. The nominal spindle speed must be reached before infeed begins.

During switch-on, the spindle follows the ramp in MP3411.x. During switch-off, it follows the ramp in MP3412.2:

- In MP3412.2, enter a multiplier for MP3411 during tapping.
- In MP3415.2, define the overshoot behavior of the spindle during tapping.
- Acknowledge the output of the M functions. An NC stop cannot be executed until a previous M function is acknowledged.

If the feed-rate and spindle ramps have differing gradients, the spindle follows the slower ramp.

Example:
Speed s = 1000 rpm
MP3411.x = 0.025 [1000 rpm/ms]

$$\frac{1000\ \text{min}^{-1}}{0{,}025 \cdot [1000\ \text{min}^{-1}/\text{ms}]} = 40\ \text{ms}$$

In this example the spindle was braked 40 ms before reaching the hole depth.

Delay times permit an optimum adjustment of the floating tap holder. You can delay the switch-off:

- In MP7120.2 enter a spindle slow-down time.

The delay cannot last longer than 30 ms before reaching the hole depth. Values above 30 ms are ignored (see the diagram).

You can delay a subsequent spindle start with M04:

- In MP7120.0 enter a dwell time. The ramp follows MP3412.2

You can delay restarting the infeed:

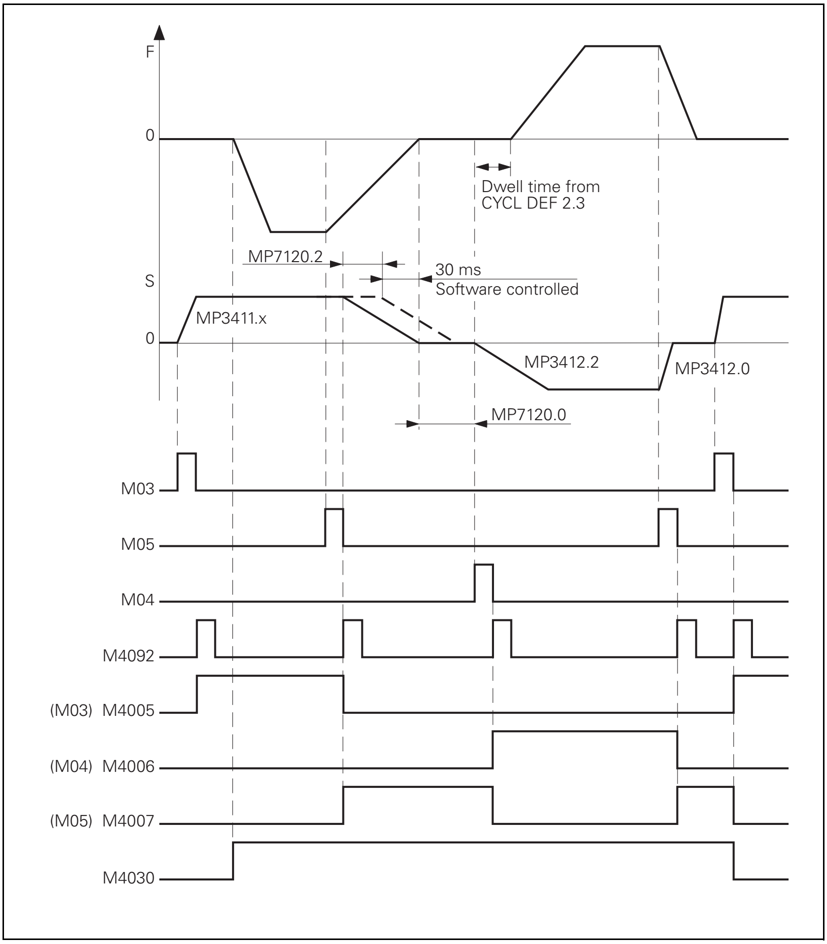
- Change the programmed dwell time in the cycle.

The NC uses M05 to switch off the spindle. The switch-off ramp follows MP3412.0. Then the spindle is switched back on with M03.

The feed-rate override for tapping must be limited. Otherwise the floating tap holder may be damaged:

- Enter a limit in MP7110.x.

The following diagram shows the time sequence of the cycle:



		Set	Reset
M4030	**Cycle 2 or Cycle 17 active**	NC	NC

MP3412.2 **Multiplier for MP3411 during tapping**
Input: 0 to 1.999

MP3415.2 **Overshoot behavior of the spindle during tapping**
Input: 0 to 1000 [ms]

MP7110.0 **Minimum for feed-rate override during tapping**
Input: 0 to 150 [%]

MP7110.1 **Maximum for feed-rate override during tapping**
Input: 0 to 150 [%]

MP7120.0 **Dwell time for reversal of spindle rotational direction**
Input: 0 to 65.535 [s]

MP7120.2 **Spindle slow-down time after reaching the hole depth**
Input: 0 to 65.535 [s]

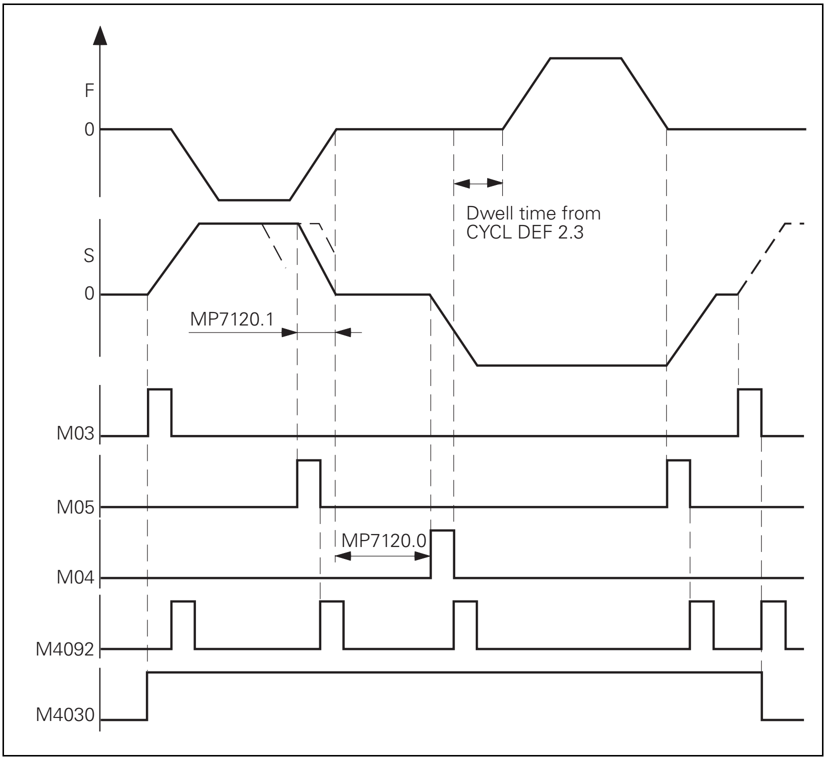
6.12.8 Tapping with Floating Tap Holder and Coded Spindle-Speed Output

If the spindle speed is output in code, the spindle and feed-rate ramps cannot be synchronized:

▶ Enter the advanced switching time of the spindle in MP7120.1.

The dwell time for rotational direction reversal (MP7120.0) and the programmed dwell time have the same effect as the nominal speed value output.

The following diagram shows the time sequence of the cycle:



MP7120.1 Advanced switching time of the spindle during tapping with coded spindle-speed output

Input: 0 to 65.535 [s]

6.12.9 Rigid Tapping

Cycle 17

- Define the rigid tapping process in the NC program with Cycle 17.
  While Cycle 17 is running, the iTNC switches automatically to velocity feedforward mode.
- Define the dynamic response of the spindle and the machine tool axes in machine parameters. See "The Control Loop" on page 6 – 113 and „Spindle" on page 6 – 193.

With Cycle 17 the spindle can also be feedback-controlled. This results in a better speed curve:

- Set MP7160 bit 2 = 1 to drive the spindle under position feedback control with Cycle 17.

The tool axis can track the spindle or it can be interpolated with the spindle. Interpolation can result in higher speed stability of the tool axis. The path jerk (spindle and tool axis) can be set via MP3415.3:

$$r = \frac{a}{MP3415.3}$$

Whichever value is smaller from this formula and from MP1090.0 is valid.

- In MP7160, set bit 4 = 1 to interpolate the tool axis with the spindle.

With small thread depths and excessive spindle speeds it is possible that the programmed spindle speed may not be attained. The immediate transition from the acceleration phase to the braking phase can diminish the quality of the thread:

- Set MP7160 bit 1 = 1 in order to limit the spindle speed so that the spindle runs for about 1/3 of the tapping time at a constant speed.

During tapping, the position of the tool axis tracks the actual position of the spindle.

Please note that the use of acceleration feedforward control for the tool axis makes the tool axis sensitive to fluctuations in spindle speed caused, for example, by gear transmission. If this happens, the tool axis starts to run rough:

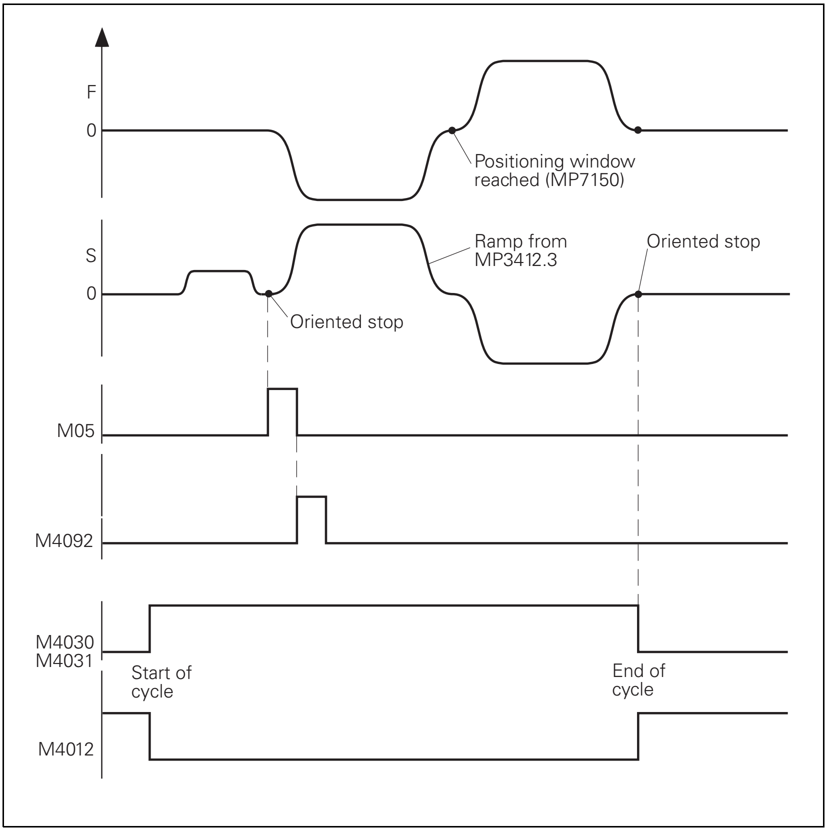
- In MP7160, set bit 3 = 1 to switch off acceleration feedforward control for Cycle 17.

Before tapping, the axes (e.g. Z and S) are synchronized through an oriented spindle stop, i.e., every Z position is assigned to a certain spindle angle. The NC orients the spindle. The NC sets M4017. The position control loop must be closed (M4012). See also „Oriented spindle stop" on page 6 – 209.

Synchronization makes it possible to cut the same thread more than once. The assigned spindle angle depends on the thread pitch entered in the cycle. You can deselect this function to save machining time:

- Set MP7160 bit 0 = 1
  In this case you cannot cut the thread more than once.

M4031 and M4030 are set while the cycle runs.

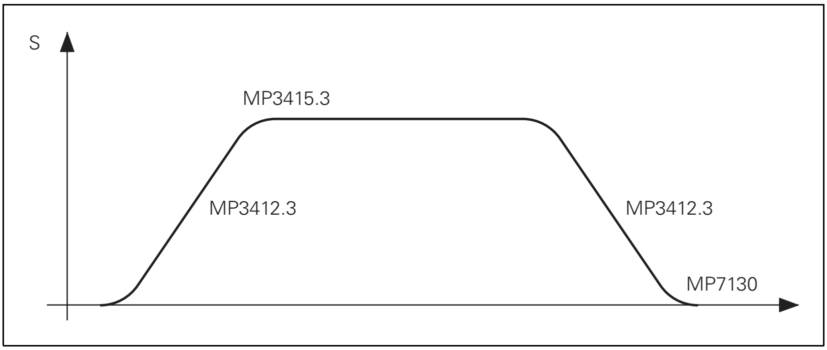


While Cycle 17 is running, the positioning window from MP7150 applies to the tool axis:

- Enter a value in MP7150 smaller than or equal MP1030.x.

Define the acceleration and braking process of the spindle during rigid tapping:

- In MP3412.3 enter a multiplier for MP3411.x.
- With MP3415.3, define the overshoot behavior of the spindle.
- With MP7130, define the run-in behavior of the spindle.



MP3412.3	**Multiplier for MP3411.x for rigid tapping**
Input:	0 to 1.999

MP3415.3	**Overshoot behavior of the first spindle during rigid tapping**
Input:	0 to 1000 [ms]

MP7130	**Run-in behavior of the spindle during rigid tapping**
Input:	0.001 to 10 [°/min]

MP7150	**Positioning window of the tool axis during rigid tapping**
Input:	0.0001 to 2 [mm]

MP7160 **Spindle response during Cycle 17, 207 and 18**

Format: %xxx

Input: Bit 0 – Oriented spindle stop with Cycles 17 and 207
0: Oriented spindle stop before execution of the cycle
1: No oriented spindle stop before execution of the cycle
Bit 1 – Spindle speed
0: Spindle speed is not limited
1: Spindle speed is limited so that it runs with constant speed approx. 1/3 of the time
Bit 2 – Spindle in position feedback control
0: Spindle operated without position feedback control
1: Spindle operated with position feedback control
Bit 3 – Acceleration feedforward
0: Active
1: Not active
Bit 4 –
0: Tool axis tracks the spindle
1: Tool axis and spindle interpolated

		Set	Reset
M4030	**Cycle 2 or Cycle 17 active**	NC	NC
M4031	**Cycle 17 or Cycle 18 active**	NC	NC

Cycle 18

With Cycle 18 the tool axis tracks the actual position of the spindle. The starting position is the actual position. The target position is the hole depth:

- Program the approach and departure separately.

M4031 is set while Cycle 18 is running. M4012 must be reset for the cycle to be executed.

MP3412.3, MP3415.3, MP7130, MP7150 and MP7160 bit 1, bit 2 and bit 3 function as for Cycle 17.

6.12.10 Switching the Modes of Operation

For a spindle motor, two parameter blocks with the same name can be saved in the motor table. This may be necessary if

- Another parameter block applies to a spindle motor at the higher speed range.
- A wye/delta connection switchover is carried out for a motor.

The switchover can be carried out during standstill or with a revolving spindle.

Danger

The protection for the wye/delta connection switchover may not be switched under load!

As soon as the operating mode is switched with Module 9163, the NC switches the drive controller of the spindle off and activates the parameter block from the motor table and the machine parameters. You can check this with Module 9162. After the operating mode has been switched, you must reactivate the drive controller of the spindle with Module 9161.

To use the operating-mode switchover:

- Enter the two parameter blocks of your spindle motor with the same name in the motor table. Identify parameter block 1 by entering 0 in the **MODE** column, and parameter block 2 by entering 1.
- Switch between the two operating modes with Module 9163.
- With Module 9161, reactivate the drive controller.

For the two operating modes, you can use different machine parameters for the current and speed controller:

- In MP131.x you enter the y index of machine parameters MP2xxx.y for the current and speed controller in operating mode 0.
- In MP132.x you enter the y index of machine parameters MP2xxx.y for the current and speed controller in operating mode 1.

Module 9163 Switching the operating modes

Call:

```
PS    B/W/D/K   <Control loop>
                15: Spindle
PS    B/W/D/K   <Type of connection>
                0: Operating mode 0
                1: Operating mode 1
CM    9163
```

Error detection:

Marker	Value	Meaning
M4203	0	No error
	1	Error code in W1022
W1022	1	Switching not possible for this control loop
	2	Incorrect operating mode or incorrect control-loop number

6.12.11 Operating a Second Spindle

With the iTNC 530 you can operate two spindles alternately, i.e., only one spindle can be active at a given time.
Both spindles can be operated as analog or digital spindles. If one spindle is to be operated as a digital spindle and the other one as an analog spindle, the first spindle must be operated as a digital spindle.

Assignment of encoder input and speed command output

The second spindle is driven instead of an axis, i.e., there are fewer axes available. An exception is analog operation of the second spindle without a position encoder. In this case all axes remain available. The assignment of position and speed encoder inputs as well as of speed command outputs is entered in MP111.x, MP113.x and MP121.x. See "Assignment for Axes" on page 6 – 13.

☞ **Note**

If the speed encoder (with active reference mark monitoring, MP2220 bit 0) is disconnected and reconnected, the reference mark must be reevaluated (M4015) after the drive has been switched on again, otherwise the error message **`Incorrect reference position`** appears.

Switching between the spindles

You can switch between the two spindles through the PLC:

- Enter MP4020 bit 5 = 1 to activate double spindle operation.
- With Module 9175, switch between spindle 1 and spindle 2.

Commissioning the second spindle

- Digital second spindle: In MP10, deactivate one axis.
- Digital second spindle: Set MP110.x, MP112.x and MP120.x of the deactivated axis to zero.
- Machine parameters MP13010 to MP13520 are available for the second spindle. In their functions and input ranges, these parameters are identical with MP3010 to MP3520 for the first spindle. See "Spindle" on page 6 – 193.
- Current and speed controller: For commissioning, use the machine parameters MP2040.x to MP2930.x. Determine the x index to be used for the second spindle with MP131.1 (for operating mode 0) and with MP132.1 (for operating mode 1).

MP4020 **PLC Functions**
Format: %xxxxxxxx
Input: Bit 5 – Single- or double-spindle operation
0: Single-spindle operation
1: Double-spindle operation

MP13010 bis MP13520 **Machine parameter block for the second spindle**
Input: Function and input range are identical to MP3010 to MP3520

Module 9175 Spindle switchover

With this module you can switch between spindle 1 and spindle 2.
When switching via an M strobe, MP7440 bit 2 must not be set. When switching via an S or G strobe, MP3030 or MP13030, respectively, must not be set. The module only needs to be called once.
Switching is only possible if

- the control is not in operation (M4176 is not set),
- the control is in operation (M4176 is set) and an M/S/T/T2/G strobe is active, or
- the machine is not currently approaching a contour (M4157 is not set).

Call:

```
PS     B/W/D/K  <Spindle number>
                0: First spindle
                1: Second spindle
CM     9175
```

Error detection:

Marker	Value	Meaning
M4203	0	Specified spindle active
	1	Error code in W1022
W1022	2	Invalid spindle number
	6	M4157 = 1 (RESTORE POSITION active)
	20	Module was called in a spawn job or submit job
	21	Missing strobe in M4176 = 1

6.12.12 C-Axis Operation

In C-axis operation, an axis and a spindle are driven alternately by the same motor.
Digital or analog operation of axis and spindle is possible. Axis and spindle may each be equipped with one position encoder. Because the speed encoder is built into the motor, it measures both the axis and the spindle.

Assignment of encoder inputs and speed command outputs to the axis and spindle:

- In MP110.x, enter the position encoder input of the axis (if present).
- In MP111.x, enter the position encoder input of the spindle (if present).
- Enter MP112.x = 0 for the axis (it uses the speed encoder of the spindle motor).
- In MP113.x, enter the speed encoder input of the spindle.
- Enter the same speed command output in MP121.x for the spindle and in MP120.x for the axis.

Commissioning of the axis and the spindle:

- The current and speed controllers are commissioned only for the spindle.
- The position controllers **must** be commissioned separately for the axis and spindle.

Note

The axis position controller should be commissioned in the gear range that is actually used for positioning.
If possible, use the lowest gear range to ensure optimum control.

C axis operation must be deselected for commissioning the spindle, meaning that no identical PWM outputs may be entered in MP120.x and in MP121.x.

If you use only one position encoder for both the spindle and the axis, the axis display keeps running while the spindle is in operation:

- Before switching from the axis to the spindle, save the actual position value of the axis with Module 9146. This ensures that the axis display remains at the last value, even when the spindle is rotating.
- Before switching from the spindle to the axis, recover the actual position value of the axis with Module 9146.

If you save the actual position value with Module 9146 and then close the position control loop, or if the position control loop is closed and the actual position value is then saved with Module 9146, the error message **`Actual position value saved <Axis>`** appears. The error message triggers an emergency stop.

Switching from **spindle to axis:**

- Stop the spindle
- Switch to the gear range required for axis operation.
- Switch the spindle motor to the axis.
- With Module 9156, switch the axis from the open-loop to the closed-loop (servo-controlled) state.
- Enable the current and speed controls via Module 9161 with the corresponding bit for the axis.
- Release the axis clamping.
- Close the position control loop of the axis by setting the corresponding bits in W1040.
- Begin axis operation

Switching from **axis to spindle:**

- Stop the axis
- Clamp the axis
- Open the position control loop of the axis by resetting the corresponding bits in W1040.
- With Module 9155, switch the feedback control for the axis off.
- Switch the spindle motor from the axis back to the spindle.
- With Module 9161 bit 15, release the current and speed controllers.
- Shift back to the original gear range.
- Begin spindle operation

Module 9146 Saving and reestablishing actual position values

Module 9146 saves and later reestablishes the actual position values of axes. If the actual position values were saved, the last value displayed remains until they are reestablished.

Call:
PS B/W/D/K <Axes bit-encoded>
PS B/W/D/K <Mode>
0: Save actual position values
1: Reestablish actual position values
CM 9146

Error detection:

Marker	Value	Meaning
M4203	0	Actual position values saved or reestablished
	1	Error code in W1022
W1022	1	Invalid mode
	2	Invalid axes
	24	Module was called in a spawn job or submit job

Module 9155 Axis switchover from closed loop to open loop

With Module 9155 you can switch an axis from the closed-loop to the open-loop state. Now the bit can be transferred to the spindle or the axis.

Call:
PS B/W/D/K <Axes bit-encoded>
CM 9155

Error detection:

Marker	Value	Meaning
M4203	0	No error
	1	Error code in W1022
W1022	2	Invalid axis number
	21	Missing strobe or M4176 = 1
	24	Module was called in a spawn job or submit job

Module 9156 Axis switchover from open loop to closed loop

With Module 9156 you can switch an axis from the open-loop to the closed-loop state. An automatic actual-to-nominal value transfer is executed. Now the bit can be transferred to the spindle or the axis.

Call:
PS B/W/D/K <Axes bit-encoded>
CM 9156

Error detection:

Marker	Value	Meaning
M4203	0	No error
	1	Error code in W1022
W1022	2	Invalid axis number
	21	Missing strobe or M4176 = 1
	24	Module was called in a spawn job or submit job

6.13 Integrated Oscilloscope

The iTNC features an integrated oscilloscope.

This oscilloscope has six channels, of which no more than four can be used for signals from the current and speed controller. If more than four channels are to be displayed from the current and speed controller, the error message **`Channel <number> cannot be displayed`** appears.

The following signals can be recorded:

Signal	Meaning
Saved	The signal last recorded is displayed
s actual	Actual position [mm]
s nominal	Nominal position [mm]
s diff	Following error of the position controller [mm]
Volt.analog	Analog axis/spindle: Analog voltage = nominal velocity value [mV]
v actual	Actual value of the axis feed rate [mm/min]. Calculated from position encoder.
v nominal	Nominal value of the axis feed rate [mm/min]. Axis feed rate calculated from the difference from the nominal position values. The following error isn’t included.
Feed rate	Contouring feed rate [mm/min]
Position: I1	Signal 1 of the position encoder
Position: I2	Signal 2 of the position encoder
v (act rpm)	Shaft speed actual value [mm/min]; Calculated from rotary speed encoder and standardized with MP1054
v (nom rpm)	Nominal velocity value [mm/min]: Output quantity of the position controller
I (int rpm)	Integral-action component of the nominal current value [A]
I nominal	Nominal current value [A] that determines torque
PLC	The PLC operands (B, W, D, I, O, T, C) are recorded. Enter the operands in the input field next to the PLC.
a nominal	Nominal value of the acceleration [m/s^2]
r nominal	Nominal value of the jerk [m/s^3]
Pos. Diff.	Difference between position and speed encoder [mm]
a actual	Current acceleration value [m/s^2]. Calculated from position encoder.
r actual	Current jerk value [m/s^3]. Calculated from position encoder.
I2-t (mot.)	Current value of the I^2t monitoring of the motor [%]
I2-t (p.m.)	Current value of the I^2t monitoring of the power module [%]
Utilization	Utilization of drive motors [%]
Block no.	Block number of the NC program
Gantry diff.	Difference between synchronous axes [mm]
U nominal	Nominal voltage [V]

Signal	Meaning
P mech.	Mechanical power [W]
P elec.	Electrical power [W]
M actual	Actual torque value [Nm]
S noml (f.)	Nominal position of nominal position value filter [mm]
DSP debug	Diagnosis function for internal purposes
Contour dev.	Circular interpolation test, contour deviation [mm]

The oscilloscope provides additional functions for commissioning the current controller. See "Commissioning" on page 6 – 234.

The recorded data remain stored until you start recording again or activate another graphic function.

Colors

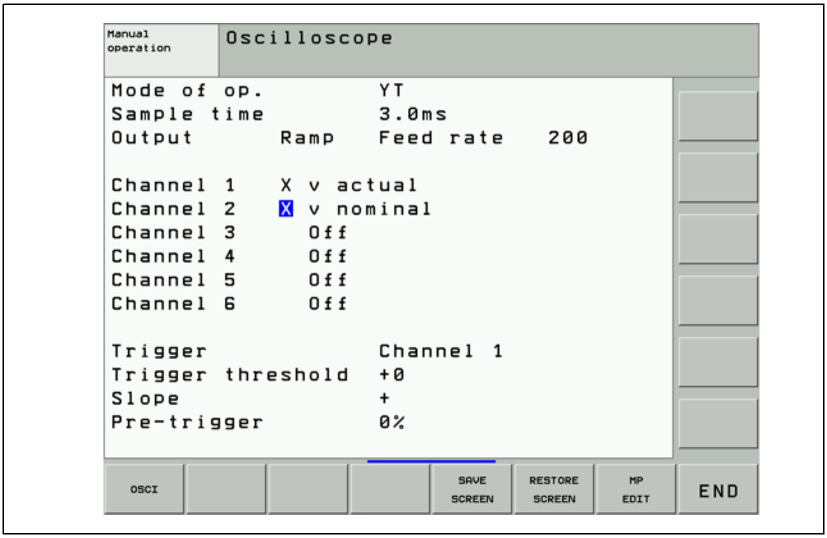
▶ In MP7365.x, define the colors for the oscilloscope.

Setup

▶ Activate the oscilloscope with the code number 688379.

After you enter the code number, the setup menu appears:

▶ Choose the parameters to be entered with the cursor keys.



Operating mode:

▶ Select the desired setting or choose the circular interpolation test

- YT: Chronological depiction of the channels
- XY: X/Y graph of two channels
- CIRC: Circular interpolation test

Sample time:

▶ Set the time interval for recording the signals.
Entry: 0.6 ms, 1.8 ms and 3.6 ms
4096 samples are stored. The signals are therefore stored for the following duration:

- 0.6 ms · 4096 = 2.4576 s
- 1.8 ms · 4096 = 7.3728 s
- 3.6 ms · 4096 = 14.7456 s

Output:

▶ Select whether the nominal speed value is to be issued as a step or ramp.

- If you select ramp output, then the programmed feed rate, k_V factors, and acceleration values that you have specified with machine parameters go into effect.
- If you select step output, a step will be output as nominal velocity value when you press the axis-direction buttons in the **Manual operating mode.** During output, the position control loop is opened.

Feed rate:

▶ Enter the height of the step for the nominal velocity value (in mm/min). This entry has no effect for ramp output.

Channel 1 to channel 6:

▶ Assign the channels of the recorded signals to the respective axes.

Trigger:

▶ Define the type of recording.
You have the following possibilities:

- **Free run:** The recording is started and ended by soft key. If you press the STOP soft key, the last 4096 events are stored.
- **Single shot:** If you press the START soft key, the next 4096 events are stored.
- **Channel 1** to **6:** Recording begins when the triggering threshold of the selected channel is exceeded.

Trigger threshold:

▶ Enter the trigger threshold (you will find the appropriate units in the signals table on Page 6–227):

Slope:

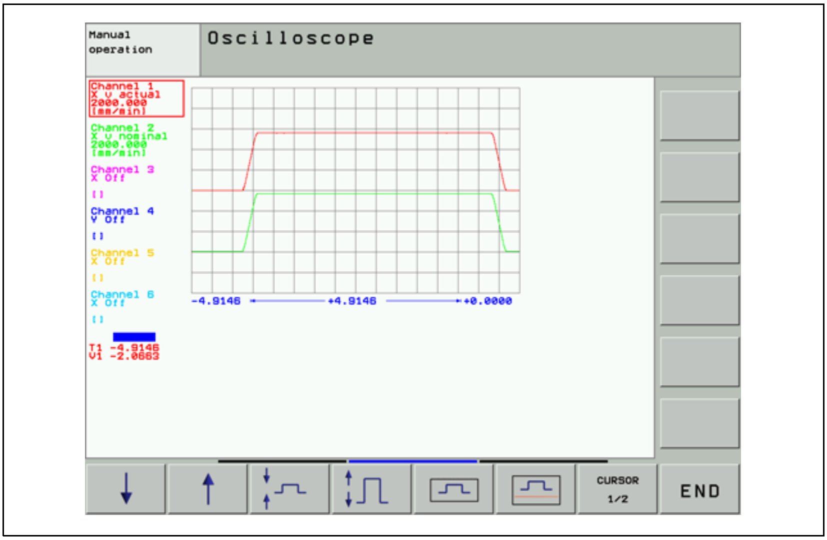
▶ Select whether the rising edge (positive slope) or falling edge (negative slope) of the signal acts as trigger.

Pre-Trigger:
Recording begins at a time preceding the trigger time point by the value entered here

▶ Enter a value.

Oscilloscope display:

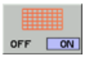
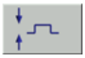
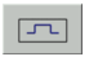
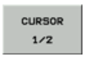
▶ Press the OSCI Soft key



During recording, the selected signals are continuously displayed. After recording ends, the memory contents are displayed. For every channel, the type of signal and the resolution are also shown. The length of the recorded range, with respect to the entire memory content, is shown as a bar in the status field.

- Move the cursor with the arrow keys to select the channel. The status field shows the amplitude of the selected channel and the time with respect to the beginning of recording.
- Activate a second cursor by pressing the CURSOR 1/2 soft key. The oscilloscope displays the amplitude and time of this cursor. The time [s] of the second cursor is shown with respect to the time point of the first cursor. With this function you can measure the acceleration time of an axis, for example.

Meaning of the soft keys:

Meaning of the soft keys:	
	Hide/show gridlines.
	Hide/show lines between measured points.
	Back to setup menu.
	Start recording. The recording is ended either with a trigger condition or with the STOP soft key.
	Move the signal down.
	Move the signal up.
	Decrease the vertical resolution.
	Increase the vertical resolution.
	Optimum vertical resolution. The signal is centered in the picture.
	Optimum vertical resolution. The signal is referenced to the datum line.
	Switch to second cursor.
	Move the signal to the left.
	Move the signal to the right.
	Decrease the horizontal resolution.
	Increase the horizontal resolution.
	Invert the signal.
	Exit the oscilloscope function.

Saving and loading a recording

You can display the signal last recorded for a channel again by selecting the Saved signal.

With the SAVE SCREEN soft key in the Setup menu you can save the recorded signals with all settings in a file on the hard disk. The file must have the extension DTA. This file can

- be called by the PLCdesign PLC development software again, or
- be read back into the control.

In order to read a *.DTA file back into the control:

- Press the RESTORE SCREEN soft key in the Setup menu.
- Enter the complete file name and path of the *.DTA file.
- Press the ENT key.
- Press the OSCI soft key to displays the signals from the *.DTA file.

Circular interpolation test

A circular interpolation test can be run in the oscilloscope.

- Choose the **`CIRC`** operating mode in the oscilloscope
- Select the **`Contour dev.`** setting for the appropriate axes in the two channels
- Begin recording
- Start an NC program in which a circle is programmed. The circle center point must be at the origin of both axes.
- Stop recording

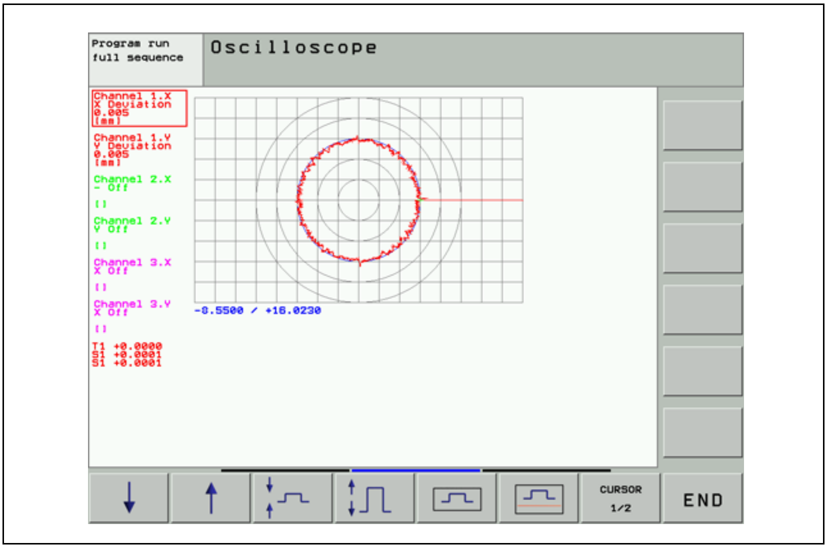
Below the grid, the recording time relative to the trigger time point is displayed.

Example of a circular interpolation test with the integrated oscilloscope:

Actual position:
X +30
Y +0

NC program:

```
0 BEGIN PGM Circular interpolation test MM
1 CC X+0 Y+0
2 CP IPA+360 DR+ F1000
3 M30
4 END PGM Circular interpolation test MM
```



6.14 Commissioning

6.14.1 Table for Power Module, Supply Module and Motor

In the machine parameter editor you select the installed power modules and the motors:

- Call a list of power modules or motors with the corresponding soft key.
  In the list of motors, the type of motor (synchronous, asynchronous, or linear motor) and the operating mode are displayed in addition to the motor designation.

Meaning of the soft keys:		
	Call a list of power modules.	
	BEGIN ↑	Jump to the beginning of the list of power modules.
	END ↓	Jump to the end of the list of power modules.
	PAGE ↓	Scroll one page forward in the list of power modules.
	PAGE ↑	Scroll one page backward in the list of power modules.
	SELECT AXIS	Select a power module with the arrow keys and transfer it with the corresponding STORE MP2100.X soft key.
	PRESENT VALUE	Open the table of power modules and jump to the selected power module.
	APPEND AMPLIFIER	Add the new power module to the table of power modules.
	END	Return to the machine parameter editor.

Meaning of the soft keys:	
M	Call a list of motors.
BEGIN ↑	Jump to the beginning of the list of motors.
END ↓	Jump to the end of the list of motors.
PAGE ↓	Scroll one page forward in the list of motors.
PAGE ↑	Scroll one page backward in the list of motors.
SELECT AXIS	Select a motor with the arrow keys and transfer it with the corresponding "STORE MP2200.X" soft key.
PRESENT VALUE	Open the table of motors and jump to the selected motor.
APPEND MOTOR	Add the new motor to the table of motors.
END	Return to the machine parameter editor.

After you have selected the motor and the power module, the models are automatically entered in MP2100.x and MP2200.x.

If you use motors or power modules that are not listed in the menus, please contact HEIDENHAIN.

You can overwrite standard data or add other models to the tables. If you change the table of the motor models or power modules, the changed tables are filed in the PLC partition:

- PLC:\MP\MOTOR.MOT (motor table)
- PLC:\MP\MOTOR.AMP (power-module table)

These tables are then taken into account by the iTNC. If at any time you want to use the HEIDENHAIN standard tables again, you must erase the above-mentioned tables in the PLC partition.

If you use a motor that appears in the motor table, but only the data for the speed encoders differs, you can overwrite this data in the motor table with MP2202.x, MP2204.x and MP2206.x. The motor table is not actually changed. The changes only take place in the operating memory.

Note

The original entry from the motor table is used only when MP2202.x = *, MP2204.x = * and MP2206.x = *.

MP2100.x **Power module model**
Input: Name of the selected power module (entered by the iTNC)

MP2200.x **Motor model**
Input: Name of the selected motor (entered by the iTNC)

MP2202.x **Overwrite “Line count” from the motor table**
Input: *: Entry from the motor table active
0: No speed encoder (volts-per-hertz control mode)
1 to 999 999

MP2204.x **Overwrite “Counting direction” from the motor table**
Input: *: Entry from the motor table active
+: Positive counting direction
–: Negative counting direction

MP2206.x **Overwrite “Type of encoder” from the motor table**
Input: *: Entry from the motor table active
0: No speed encoder (volts-per-hertz control mode)
1: Incremental rotary encoder with Z1 track
2: Absolute rotary encoder with EnDat interface (aligned)
3: Absolute linear encoder with EnDat interface
4: Reserved
5: Absolute rotary encoder with EnDat interface (not aligned)
6: Incremental rotary encoder without Z1 track
7: Incremental rotary encoder with distance-coded reference marks (not aligned)
8: Incremental linear encoder with distance-coded reference marks (not aligned)

Entries in the power module table:

- Designation of power module (NAME)
- Maximum current (I-MAX) in A
- Rated current (I-N) in A at a PWM frequency of 5 kHz
- Current sensor voltage (U-IMAX) in V at I-MAX
- Permissible continuous current in stationary rotating field or until F-DC is reached (I-N-DC) in A
- Time constant, how long maximum current can be applied to a stationary synchronous motor (T-DC) in seconds
- Lower motor base frequency down to which the motor can be loaded with I-N-DC (F-DC) in Hz
- Cycle duration for the duty cycle S6-40%(T-AC) in seconds
- Motor frequency from which I-MAX is permissible (F-AC) in seconds
- Protection time of the IGBTs (T-IGBT) in seconds
- Rated currents with PWM frequencies of 3333 Hz, 4000 Hz, 5000 Hz, 6666 Hz, 8000 Hz and 10000 Hz (I-N-AC-3333, I-N-AC-4000, I-N-AC-5000, I-N-AC-6666, I-N-AC-8000, I-N-AC-10 000) in A

Entries in the power supply module table:

- Designation of power supply module (NAME)
- Type of power supply module (E/R)
  - 0 = Nonregenerative
  - 1 = Regenerative
- Rated power output (P-N) in W
- Peak power for the duty cycle S6-40% (P-S6-40) in W
- Peak power for 0.2 s (P-MAX02) in W
- DC-link voltage (UZ) in V
- Analog value of the dc-link voltage with HEIDENHAIN power supply modules (UZ-AN) in V/V
- Analog value of the dc-link current with HEIDENHAIN power supply modules (IZ-AN) in V/A
- Status signals of the HEIDENHAIN power supply modules
  - Bit 0: Signal $\overline{\text{PF.PS.AC}}$ (AC fail)
  - Bit 1: Signal $\overline{\text{PF.PS.ZK}}$ (power fail)
  - Bit 2: Signals $\overline{\text{ERR.TEMP}}$ (temperature)
  - Bit 3: Signal RDY.PS (ready)
  - Bits 4 to 7: reserved

Entries in the motor table:

- Motor model (TYPE)
  - UASM = Uncontrolled asynchronous motor (volts-per-hertz control mode)
  - SM = synchronous motor
  - ASM = asynchronous motor
  - LSM = linear motor

- Designation of motor (NAME)
- Operating mode (MODE)
- Rated current (I-N) in A
- Rated voltage (U-N) in V
- Rated speed (N-N) in rpm
- Rated frequency (F-N) in Hz
- No-load voltage (U0) in V
- No-load current (I0) in A
- Stator resistance cold (R1) in mΩ
- Rotor resistance cold (R2) in mΩ
- Stator leakage reactance (XStr1) in mΩ
- Rotor leakage reactance (XStr2) in mΩ
- Magnetizing reactance (XH) in mΩ
- Upper speed X-H characteristic (N-XH) in rpm
- Threshold speed for field weakening (N-FS) in rpm
- Maximum speed (N-MAX) in rpm
- Factor for X-H characteristic (%-XH)
- Factor for stalling torque reduction (%-K)
- Number of pole pairs (PZ)
- Temperature coefficient (TK) in Ω/K
- Line count of the motor encoder (STR)
- Encoder being used (SYS)
  - 0 = No speed encoder (volts-per-hertz control mode)
  - 1 = Incremental rotary encoder with Z1 track
  - 2 = Absolute rotary encoder with EnDat interface (aligned[1])
  - 3 = Absolute linear encoder with EnDat interface
  - 4 = Reserved
  - 5 = Absolute rotary encoder with EnDat interface (not aligned[1])
  - 6 = Incremental rotary encoder without Z1 track
  - 7 = Incremental rotary encoder with distance-coded reference marks (not aligned[1])
  - 8 = Incremental linear encoder with distance-coded reference marks (not aligned)

- Counting direction of the motor encoder (DIRECT.)
- Maximum temperature (T-MAX) in °C
- Maximum current (I-MAX) in A
- Rated power output (P-N) in W
- Motor mass moment of inertia (J) in kgm^2
- Inductance of the series reactor (L) in µH
- Thermal time constant for direct current (T-DC) in seconds
- Lower thermal limit frequency (F-DC) in Hz
- Thermal time constant for alternating current (T-AC) in seconds
- Upper thermal limit frequency (F-AC) in Hz; above this frequency, the maximum current I-MAX applies

---

1. See “Field Orientation” on page 6 – 244

Series reactor

The inductivity of the series reactor is calculated depending on the no-load current I0:

I0 < 26 A:

$$L = \frac{700\ \mu H \cdot 5000\ Hz}{f_{PWM}} - \frac{(X_1 + X_2) \cdot 1000}{2 \cdot \pi \cdot f_N}$$

I0 ≥ 26 A:

$$L = \frac{U_Z \cdot 10^6}{6{,}66 \cdot I_0 \cdot f_{PWM}} - \frac{(X_1 + X_2) \cdot 1000}{2 \cdot \pi \cdot f_N}$$

- L: Inductance of the series reactor in µH
- f_{PWM}: PWM frequency [Hz]
- X_1: Stator leakage reactance [mΩ]
- X_2: Rotor leakage reactance [mΩ]
- f_N: Rated frequency [Hz]
- U_Z: DC-link voltage [V]
- I_0: No-load current [A]

A negative result means that there is no series reactor.

Note

If a series reactor is installed later, the current controller must be readjusted.

The series reactor must fulfill the following specifications:

- The required inductivity (per phase)
- Load capacity with the maximum spindle current
- The inductivity even with the maximum spindle speed (operating frequency)

6.14.2 PWM Frequencies of the CC 422

For the CC 422, certain controller groups can be assigned different PWM frequencies via MP2180.x.

The PWM outputs of a controller group must be assigned the same PWM frequencies with MP2180.x. Otherwise, the DSP error message **`C440 PWM frequency <Axis> incorrect`** will appear.

- Controller group 1: X51, X53, X54
- Controller group 2: X52, X55, X56
- Controller group 3: X57, X59, X60
- Controller group 4: X58, X61, X62

▶ With MP2180.x, you can set the same PWM frequency for the PWM outputs of a controller group. The assignment between a PWM output and MP2xxx.y is done with MP120.x/MP121.x and MP130.x/MP131.x/MP132.x.

If PWM frequencies of > 5000 Hz are set for a controller group, it is no longer possible to use all PWM outputs of the controller group. Then only the first PWM output of the controller group can be used. The other PWM outputs must not be entered in MP120.x or MP121.x. Otherwise, the DSP error message **`C440 PWM frequency <Axis> incorrect`** will appear.

The following PWM outputs can be operated with a PWM frequency of > 5000 Hz:

- Controller group 1: X51 (but not X53, X54)
- Controller group 2: X52 (but not X55, X56)
- Controller group 3: X57 (but not X59, X60)
- Controller group 4: X58 (but not X61, X62)

▶ Set the required PWM frequency > 5000 Hz for the corresponding PWM output in MP2180.x. For the PWM outputs not used for the controller group, set MP2180.x = 0.

Warning

The following hardware version and later versions support the entry of different PWM frequencies for controller groups and of PWM frequencies > 5000 Hz:

- CC 422/6 control loops with Id. Nr. 359 651-02
- CC 422/10 control loops with Id. Nr. 359 652-02
- CC 422/12 control loops with Id. Nr. 359 653-02

If you are using another hardware version, you must enter the same value (≤ 5000 Hz) in all MP2180.x.

MP2180.x **PWM frequency**

Input: 0: f_{PWM} = 5000 Hz (for HEIDENHAIN inverters)
3200 to 3999: f_{PWM} = 3333 Hz
4000 to 4999: f_{PWM} = 4166 Hz
5000 to 5999: f_{PWM} = 5000 Hz
6000 to 7999: f_{PWM} = 6666 Hz
8000 to 9999: f_{PWM} = 8333 Hz
10000: f_{PWM} = 10000 Hz

PWM frequency with INDRAMAT "POWER DRIVE" inverters

▶ In MP2180.x, enter the PWM frequency 4000 Hz.

PWM frequency with SIEMENS "SIMODRIVE" inverters

The iTNC 530 operates with a PWM frequency of 5 kHz. SIEMENS power modules are normally driven with a PWM frequency of 3.2 kHz (spindle) and 4 kHz (axes).
The rated current values I_N are defined for these frequencies. If power modules are operated with a higher PWM frequency (e.g. 5 kHz), high temperatures can be caused in these modules in some cases.

This applies particularly to these SIEMENS power modules:

- 6SN1123-1AA00-0CA0 (as axis module)
- 6SN1123-1AB00-0CA0 (as axis module)

Machines that are not under full load do not exceed the maximum permissible temperature.

There are two ways to prevent the undesired heating:

▶ In MP2180.x, enter the required PWM frequency (3200 Hz or 4000 Hz)
or

▶ Reduce the factor for I^2t monitoring
or

▶ Reduce rated current I_N in the table of power modules.

Note

A reduction of the PWM frequency has no effect on the maximum speed, but it means that the axis and the spindle(s) must be commissioned again.

For the commissioning of new machines, HEIDENHAIN recommends adjusting the PWM frequency to fit axis modules (normally 4 kHz, see SIEMENS documentation). If the power module of the spindle gets too warm in spite of a reduction of the PWM frequency from 5 kHz to 4 kHz, then the reference value for the I^2t monitoring or the rated current I_N must be reduced in the table of power modules.

Reduction of the reference value for I^2t monitoring or rated current I_N in the table of power modules

The reduction of the rated current I_N of the power modules, as well as the datum value for I^2t monitoring, can be calculated from two values (X1, X2) that are given in the SIEMENS documentation.

The percent reduction of the rated current can be calculated with the following formula:

$$X_R[\%] = 100 - \left(\frac{(100 - X1) \cdot (8\ \text{kHz} - f_{PWM})}{8\ \text{kHz} - X2} + X1\right)$$

- X1 = Reduction factor of the current in % at a PWM frequency of 8 kHz
- X2 = PWM threshold frequency in kHz at which the electrical power reduction begins
- f_{PWM} = Frequency in kHz set in MP2180.x

This results in the reference value for I^2t monitoring:

$$X_B = 1 - \frac{X_R[\%]}{100}$$

- Reduce the rated current values I_N of your power modules in the list of power modules.

$$I_{Nneu} = I_N \cdot (100\ \% - X_R[\%])$$

Or

- Reduce the reference value for the I^2t monitoring.

$$MP2302.x = X_B$$

Note

A reduction of the rated current of the power module can cause a reduction of the rated torque and, as a consequence, the rated power of the motor, if equal values for rated current of the power module and the rated current of the motor were chosen.

Example for a 50-A power module:

- Axis power module with 50 A, PWM frequency of 5 kHz, X1 = 40%, X2 = 4 kHz

$$X_R[\%] = 100 - \left(\frac{(100 - 40) \cdot (8\ \text{kHz} - 5\ \text{kHz})}{8\ \text{kHz} - 4\ \text{kHz}} + 40\right) = 15\ \%$$

$$X_B = 1 - \frac{15}{100} = 0,85$$

- Spindle power module with 50 A, PWM frequency of 5 kHz, X1 = 40%, X2 = 3.2 kHz

$$X_R[\%] = 100 - \left(\frac{(100 - 40) \cdot (8\ \text{kHz} - 5\ \text{kHz})}{8\ \text{kHz} - 3{,}2\ \text{kHz}} + 40\right) = 22{,}5\ \%$$

$$X_B = 1 - \frac{22{,}5}{100} = 0{,}78$$

- Axis power module with 50 A, PWM frequency of 4 kHz, X1 = 40%, X2 = 4 kHz

$$X_R[\%] = 100 - \left(\frac{(100 - 40) \cdot (8\ \text{kHz} - 4\ \text{kHz})}{8\ \text{kHz} - 4\ \text{kHz}} + 40\right) = 0\ \%$$

$$X_B = 1 - \frac{0}{100} = 1,00$$

- Spindle power module with 50 A, PWM frequency of 4 kHz, X1 = 40%, X2 = 3.2 kHz

$$X_R[\%] = 100 - \left(\frac{(100 - 40) \cdot (8\ \text{kHz} - 4\ \text{kHz})}{8\ \text{kHz} - 3{,}2\ \text{kHz}} + 40\right) = 10\ \%$$

$$X_B = 1 - \frac{10}{100} = 0,90$$

6.14.3 Field Orientation

If a synchronous spindle or a torque motor is used along with an encoder without Z1 track or a nonaligned encoder with EnDat interface, there is no assignment between the encoder and rotor magnets.

The Field Orientation function, which must be carried out once, is used by the iTNC 530 to automatically determine the association between the encoder and rotor magnets (field angle), and stores this information internally.

Note

The field angle can be determined only if the current controller is already adjusted!

Encoder with EnDat interface	Encoder without Z1 track
As soon as the absolute position of the encoder has been read, the absolute position and determined field angle are associated. The field angle is associated with the zero position of the encoder.	After switching on the drive, the motor orients itself (rough orientation). The drive is ready for operation after this procedure. The field angle is determined and associated as soon as the reference mark is traversed during the first motor motion.

The are two methods for determining the field angle:

- The field angle is determined automatically when the drive is first switched on. The field angle is stored after it has been determined. This field angle is used when the motor is switched on again. The **FIELD ORIENT.** soft key has no function.
- By pressing the **FIELD ORIENT.** soft key once while the motor is being commissioned. After pressing the soft key, the motor rotates. The field angle is determined and stored during this motion. This field angle is used when the motor is switched on again.

▶ Select the method for field angle determination in MP2254.x.

MP2254.x **Determining the field angle**

Input: 0: Field angle is determined during operation; soft key has no function

1: Only CC 422: Field angle is determined via soft key; motor motion is permitted

Danger

If the speed encoder is exchanged, the Field Orientation function must be rerun.

Note

For synchronous spindles, the field angle should be determined via the **FIELD ORIENT.** soft key, since this is a more exact determination.

Each time that a drive with a speed encoder without a Z1 track is switched on, the drive is automatically traversed over the speed encoder's reference mark in order so that the field angle may be established. The **Finding field angle** message appears during this motion.

Determining the field angle during operation

The field angle is determined automatically when the drive is first switched on. The motor moves back and forth for approximately four to six seconds. The **Finding field angle** message appears.

If the power module is not active before the determination of the field angle begins, the error message **8B40 No drive release <axis>** appears. If the power module switches off during the determination, **8B50 Axis module <axis> not ready** appears.

Note

Standstill monitoring is active while determining the field angle. If it responds, increase the threshold in MP1110.x. Afterwards, reset MP1110.x to the original value.
As of NC software 340 422-03 and 340 480-03 , you can set the threshold for standstill monitoring during the field orientation separately in MP1120.x

Determining the field angle via the FIELD ORIENT. soft key

- Switch on the control.
- Do **not** acknowledge the **Power Interrupted** message. In the **Programming and Editing** mode of operation, use the MOD key to enter the code number **688379.** The oscilloscope is started.
- Press the **I CONTROL** soft key.
- In the **Manual** mode of operation, acknowledge the **Power Interrupted** message.
- Use the **CHOOSE AXIS** soft key in the oscilloscope to select the corresponding axis.
- Press the **FIELD ORIENT.** soft key.

The PLC must

- switch the drive on/off
- release and lock the brakes

The motor rotates back and forth for several minutes. The field angle is determined for the reference mark or datum, and is stored automatically. The **Finding field angle** message appears.

Note

Standstill monitoring is active while determining the field angle. If it responds, increase the threshold in MP1110.x. Afterwards, reset MP1110.x to the original value.
As of NC software 340 422-03 and 340 480-03 , you can set the threshold for standstill monitoring during the field orientation separately in MP1120.x

- Press the END soft key.

The control carries out a reset. Then the assignment of the field angle is available.

MP1120.x **Standstill monitoring when determining the field angle**
Input: 0.0000 to 300.0000 [mm] or [°]

Saving the Determined Field Angle

NC software: 340 420-xx, to 340 422-02 and to 340 480-03
The determined field angle is automatically stored on the hard disk.
If the Field Orientation function is not run, the following error message appears:

- Encoder with EnDat interface: **8830 EnDat: no field angle <axis>**
- Encoder without Z1 track: **8820 Field angle unknown <axis>**

NC software: as of 340 422-03, as of 340 480-03
The determined field angle is automatically entered in MP2556.x.

For purposes of reliability and redundancy, either the serial number of the encoder (only for EnDat interface) or a unique control ID is entered as identification in MP2257.x.

If the current identification does not match the entry in MP2257.x, an error message appears:

- When using an encoder with EnDat interface, the error message **8830 EnDat: no field angle <axis>** appears. In any case the field angle must be determined anew, since the encoder does not match the field angle from MP2256.x
- When using an incremental encoder, the error message **MP2257.<index> incorrect (ID=$<identification>)** appears. The field angle from MP2256.x and the new identification **(ID=$<identification>)** for MP2257.x can only be assumed after determining that the same drive is meant (e.g. after changing controls).

Danger

In all other cases the field angle must be determined anew, since otherwise uncontrolled drive motions could occur!

MP2256.x **Determined field angle**
Input: 0: Field angle does not need to be determined, or has not been determined

MP2257.x **Control or encoder identification for the field angle from MP2256.x**
Input: 0: Field angle does not need to be determined, or has not been determined

6.14.4 Preparation

Proceed as follows:

- Check the wiring against the grounding diagram and the safety concept (See "Basic Circuit Diagram" at the end of Chapter 3).
- Check the control-is-ready function.
  See "EMERGENCY STOP monitoring" on page 6 – 189
- Check the EMERGENCY STOP circuit by pressing the EMERGENCY STOP buttons and the EMERGENCY STOP limit switch.
- Select the current machine parameter file. Determine input values using the documentation on hand. Enter temporary values for machine parameters that must be optimized during commissioning.
- Create a PLC program for interfacing the control to the machine (use the PLC development software PLCdesign).
- Ensure that in the system file OEM.SYS the instruction **`PLCMAIN=`** refers to the current PLC program.

dc-link voltage

The iTNC 530 uses the dc-link voltage to calculate the maximum motor voltage:

- In MP2190, enter the dc-link voltage at the power module.

MP2190 **DC-link voltage U_Z**
Input: 0 to 10 000 [V]
HEIDENHAIN inverters:
UE 2xx, UE 2xxB, UV 130: 565 V
UR 2xx, UV 120, UV 140, UV 150: 650 V

Temporary input values

- Enter the following temporary input values when you begin commissioning:

MP	Temporary input value	Meaning
MP20.0	%00000000000000	Monitoring the absolute position of the distance-coded reference marks
MP1030.x	0.01	Positioning window
MP1054.x	?	Linear distance of one motor revolution (depends on the machine)
MP1090.x	1	Maximum permissible jerk on the tool path
MP1092	<greater than rapid traverse>	Feed rate threshold from which MP1090.1 becomes effective
MP1095	0	Single filter
MP1096	0	Position nominal value filter off
MP1099.0	5	Minimal filter order for single filters
MP1099.1	3	Minimal filter order for double filters
MP1110.x	2.0	Standstill monitoring
MP1140.x	0.03	Movement monitoring (for digital axes the minimum value is entered)
MP1144.x	0	Motion monitor for position and speed

MP	Temporary input value	Meaning
MP1340.x	0	No evaluation of reference marks
MP1396.x		Feedback control with velocity semi-feedforward
MP1410.x	0.5	Position monitoring in operation with velocity feedforward control (erasable)
MP1420.x	2	Position monitoring in operation with velocity feedforward control (EMERGENCY STOP)
MP1510.x	1	k_V factor for velocity feedforward control
MP1521.x	0	Transient response during acceleration and deceleration
MP1710.x	50	Position monitoring in operation with following error (erasable)
MP1720.x	50	Position monitoring in operation with following error (EMERGENCY STOP)
MP1810.x	1	k_V factor for control with following error
MP1820.x	1	Multiplier for the k_V factor
MP1830.x	100	Characteristic curve kink point
MP2220.x	%0000100	Monitoring functions
MP2400.x	0.1	Gain for current controllers
MP2500.x	0.5	Proportional factor of the shaft speed controller
MP2510.x	20	Integral factor of the motor speed controller (for axes with holding torque, e.g. vertical axes, the value 1 must be entered because otherwise the axis drifts away)
MP2512.x	0	Limiting the integral factor of the speed controller
MP2520.x	0	Differential factor of the shaft speed controller
MP2530.x	0	PT_2 element of the speed controller
MP2540.x	0	Band-rejection filter damping
MP2550.x	0	Band-rejection filter for center frequency
MP2600.x	0	Acceleration feedforward
MP2602.x	0	IPC time constant T_1
MP2604.x	0	IPC time constant T_2
MP2606.x	0	Following error in the jerk phase
MP2610.x	0	Friction compensation at low motor speed
MP2612.x	0	Delay of the friction compensation
MP2620.x	0	Friction compensation at rated speed
MP2630.x	0	Holding current

Additional temporary input values for the spindle

▶ Enter the following additional temporary input values when you begin commissioning the spindle:

MP	Temporary input value	Meaning
MP3010.x	3 to 8	Output of speed, gear range
MP3020	991	Speed range
MP3411.x	1.999	Ramp gradient
MP3412.x	1	Multiplier for MP3411.x
MP3415.x	0	Overshoot behavior
MP3420	1	Positioning window
MP3440.x	1	k_V factor

Note

C-axis operation must be deselected for commissioning, meaning that no identical PWM outputs may be entered in MP120.x and in MP121.x.

Operating-mode switchover

During commissioning you can switch between operating mode 0 and operating mode 1 with the CONNECT STAR DELTA soft key. With Module 9168 you can interrogate the current settings in the PLC. You can switch the motor using PLC outputs and activate the corresponding machine parameters with Module 9163:

▶ Perform the adjustment for operating mode 0 and operating mode 1.

- If you do not use operating mode 1, set the corresponding machine parameters to zero.

6.14.5 Commissioning Digital Control Loops with TNCopt

In order to commission digital control loops with TNCopt, you must carry out preparations on the control as described in this chapter. Also pay attention to the notes in the documentation for TNCopt. Functions not supported by TNCopt must be commissioned manually (See "Commissioning of Digital Axes" on page 6 – 254 and See "Commissioning the Digital Spindle" on page 6 – 283).

When commissioning with TNCopt, the machine axes must be moved. For safety purposes, a function of this type should be enabled on the control. The entry **TNCOPT.LOCKSOFTKEYVISIBLE = YES** in OEM.SYS makes the soft key **TNCOPT OFF ON** visible after pressing the MOD key. It is used to enable such functions. As a default, the soft key is always set to **OFF** when the control is started up.

Current controller

- Switch on the control.
- Do **not** acknowledge the **Power Interrupted** message. In the **Programming and Editing** mode of operation, use the MOD key to enter the code number 688379 to switch to the **Oscilloscope** mode of operation.
- Press the I CONTROL soft key.
- Acknowledge the **Power Interrupted** message in the **Manual** mode of operation.
- Switch on the control voltage.
- Switch to the **Oscilloscope** mode of operation.
- Press the START STEP soft key.
- Commission the current controller with TNCopt.

Speed Controller

- Position the axis or spindle to be optimized at a location where it can be commissioned safely.
- Set MP1340.x = 0 to deselect evaluation of the reference marks.
- Ensure that the loaded PLC program fulfills the following conditions:
  - Position control loop is opened, because the NC opens the position control loop only during the step function. If the position controller is not optimized, error messages appear if the position control loop is closed.
  - Enable the drive controller
  - NC stop inactive
  - Axis direction buttons active
  - Axes clamped
- In the **Programming and Editing** mode of operation, use the MOD key to enter the code number 688379 to switch to the **Oscilloscope** mode of operation.
- Set the following values in the **Oscilloscope:**
  Output: Step
  Feed rate: 100
  Channel 1: I nominal
  Trigger: Free run
- Press the OSCI soft key to switch the curve representation.
- Press the START soft key to start recording.
- Set the feed-rate override potentiometer to 100%.
- Commission the speed controller with TNCopt.

Feedforward

- Position the axes to a location where the feedforward functions can be commissioned safely.
- Set the datum for the affected axes at this location.
- In MP1060.x, set the acceleration to 0.5.
- In the **Program Run, Full Sequence** mode of operation, select the NC program **FF_*.H** (* = axis to be optimized) from the **TNC:\TNCOPT** folder.

Note

TNCopt generates the NC programs FF_*.H with the feed-rate values 6000 and 200. The larger feed-rate value should equal the machine's highest machining feed rate. Adjust the value if necessary. The lower feed-rate value must not be changed.

- Set the feed-rate override potentiometer to 100%.
- Commission the feedforward functions with TNCopt.

Reversal spikes

- Position the axes to a location where the reversal-spike compensation can be commissioned safely.
- Set the datum for the affected axes at this location.
- In MP1060.x, set the acceleration to 0.5.
- In the **Program Run, Full Sequence** mode of operation, select the NC program **CIR_*#.H** (* = axis to be optimized; # = second control loop, defines the plane) from the **TNC:\TNCOPT** folder.
- Set the feed-rate override potentiometer to 100%.
- Commission the reversal-spike compensation with TNCopt.

IPC and k_V factor

- Position the axes to a location where the IPC and k_V factor can be commissioned safely.
- Set the datum for the affected axes at this location.
- Set the k_V factors in MP1510.x to 1.
  You can also start with a higher value for MP1510, as long as the value is safely below the oscillation limit.
- In the **Program Run, Full Sequence** mode of operation, select the NC program **IPC_*.H** (* = axis to be optimized) from the **TNC:\TNCOPT** folder.
- Set the feed-rate override potentiometer to 100%.

Note

Ensure that the machine parameters for the IPC (MP2602.x, MP2604.x and MP2606.x) have been set to 0.

- Adjust the IPC and k_V factor with TNCopt.

6.14.6 Commissioning of Digital Axes

The iTNC must be adjusted in sequence for the:

- Current controller
- Speed controller
- Position controller

The signals that you need are recorded with the integral oscilloscope.

Current controller

Use the integrated oscilloscope to adjust the current controller. The speed and position control loops are open when you adjust the current controller. You must therefore activate a special PLC commissioning program:

- Enter the name of this PLC program in the OEM.SYS file with the **PLCPWM =** instruction.

It suffices to program an EM (end module).

The drive must be enabled externally and the iTNC needs the "ready" signal.

As soon as the PLC program defined with **PLCPWM =** is active, you can use Module 9168 to interrogate the commissioning status.

Module 9168 Interrogating the commissioning status

Call:

```
CM   9168
PL   D        <Status>
              –1: Commissioning not active or as yet no axis is selected
              Bits 0 to 5 represent selected axes 1 to 6
              Bit 15 – Spindle selected
              Bit 16 – Operating mode of spindle
              0: Operating mode 0
              1: Operating mode 1
```

Adjusting the current controller:

- Switch on the control.
- Do not acknowledge the **Power Interrupted** message. In the **Programming and Editing** mode of operation, use the MOD key to enter the code number **688379**. The oscilloscope is started.
- Press the I CONTROL soft key.
- In the **Manual** mode of operation, acknowledge the **Power Interrupted** message.
- Use the CHOOSE AXIS soft key in the oscilloscope to select the axis to be adjusted.
- With the I FACTOR / P FACTOR soft key, select the I factor and set MP2430.x = 0.
- With the I FACTOR / P FACTOR soft key, select the P factor.
- Calculate the starting value of the P factor with the following formula:

$$\text{Starting value} = \frac{100\,000 \cdot L}{T_a}$$

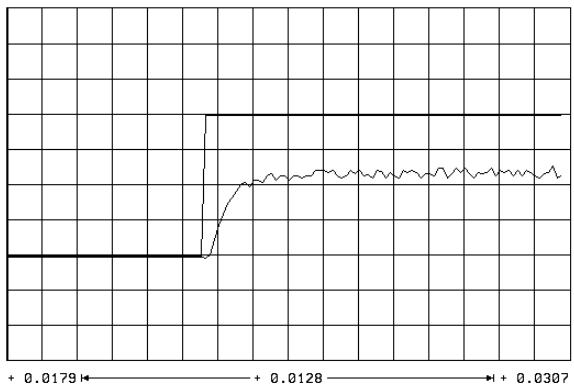
T_a	**f_{PWM} (MP2180.x)**
150	3 333 Hz
120	4 166 Hz
100	5 000 Hz
75	6 666 Hz
60	8 333 Hz
50	10 000 Hz

Synchronous motor: $L = \frac{XH}{2 \cdot \pi \cdot (F\text{-}N) \cdot 1000}$

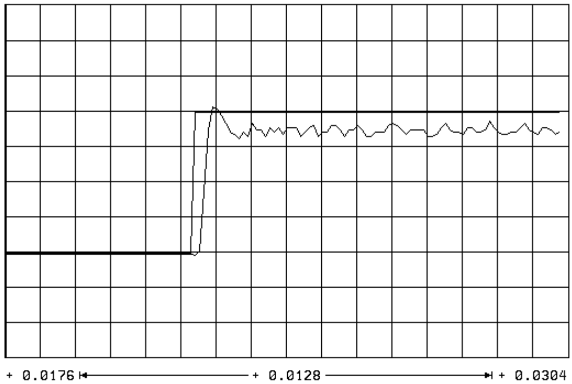
Asynchronous motor: $L = \frac{XStr1 + XStr2}{2 \cdot \pi \cdot (F\text{-}N) \cdot 1000}$

The values for XH (magnetizing reactance), F-N (rated frequency), XStr1 (stator leakage reactance) and XStr2 (rotor leakage reactance) can be found in the motor table. Switch to the editing mode of the motor table (APPEND MOTOR soft key).
The values for XH, XStr1 and XStr2 are specified in [mΩ] in the motor table. Use these values in the formulas. The formula already contains the conversion factor.

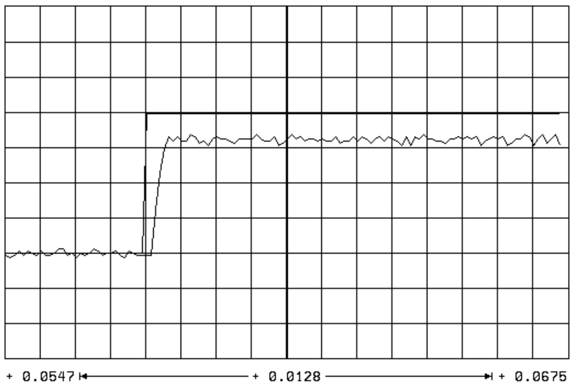
- Set this P factor (MP2420.x) with the ↑ soft key.
- Press the START STEP soft key.
  This sends a step function to the current controller and measures the step response. The height and length of the step function are automatically calculated by the iTNC.
- With the ↑ soft key, increase the P factor (MP2420.x) step by step until just barely no undershoot is visible.



MP2420.x too small



MP2420.x too large

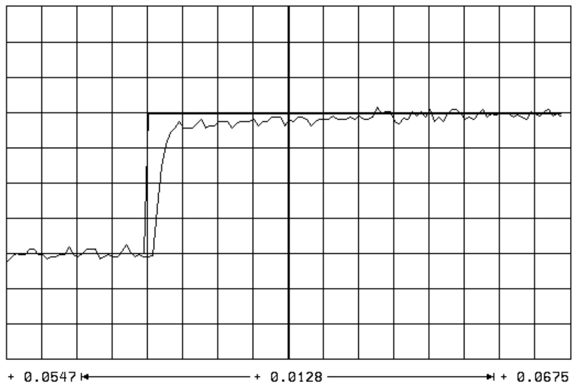


MP2420.x optimum

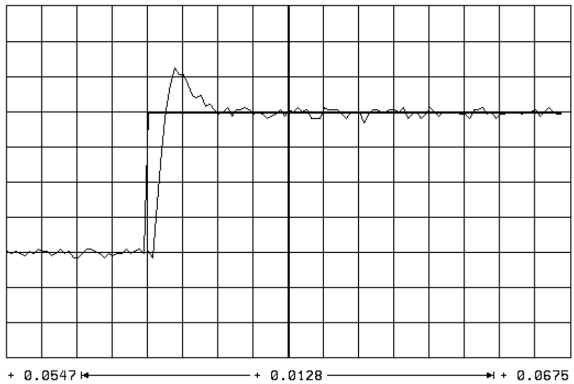
- Save this value with the STORE MP2420.x soft key.
- With the I factor / P factor soft key, select the I factor.

▶ With the ↑ soft key, increase the I factor (MP2430.x) step by step until

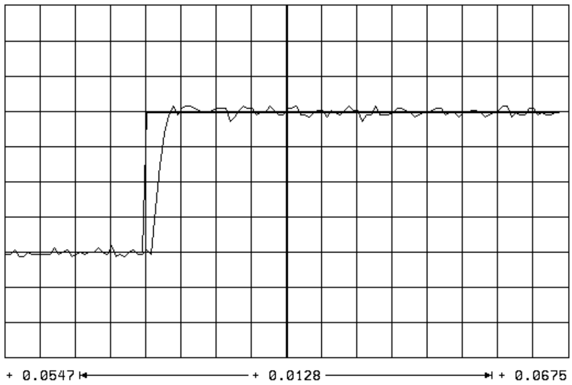
- Spindle: Just barely no overshoot is visible, and so that the nominal value is reached as quickly as possible (short rise time).
- Axes: You see an overshoot but no undershoot.



MP2430.x too small



Axes: MP2430.x optimum



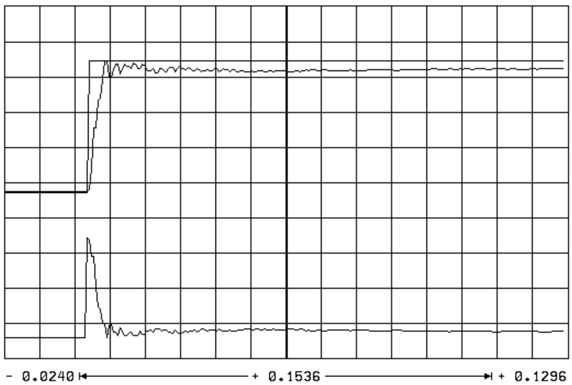
Spindle: MP2430.x optimum

- Save this value with the STORE MP2430.x soft key.
- Press the END key to exit the **Commission Current Controller** mode.

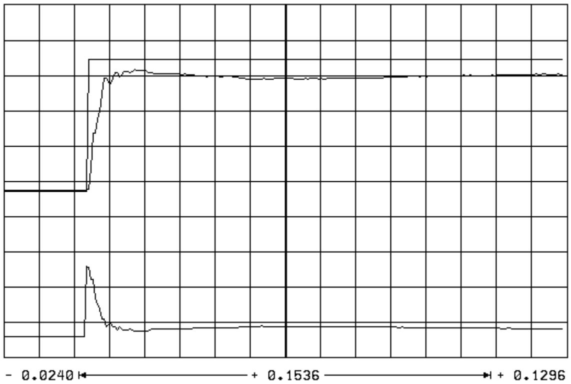
Speed Controller

Adjusting the speed controller:

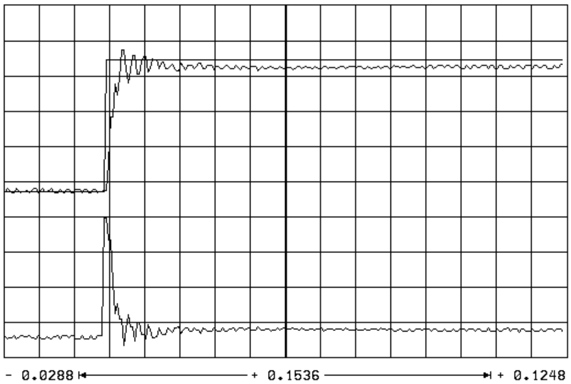
- Deselect “Pass over reference point” by setting MP1340 = 0.
- Ensure that the loaded PLC program fulfills the following conditions:
  - Position control loop is opened (W1038/W1040), because the NC opens the position control loop only during the step function. If the position controller is not optimized, error messages appear if the position controller is closed.
  - Servo drive controller is enabled (Module 9161)
  - NC stop is inactive, MP4560 = 1
  - Axis direction buttons active
  - Axes clamped
- In the MANUAL mode, use the oscilloscope function to select a step function (approx. 500 mm/min) that will not overdrive the speed controller, i.e. that does not limit I NOMINAL.
  Display the nominal velocity value V (NOM RPM), the actual speed value V (ACT RPM) and the nominal current value I NOMINAL.
- Activate the step function with the axis direction buttons.
- To change the machine parameters, press the MP EDIT soft key in the setup menu.
- Increase MP2500.x (P factor) up to the oscillation limit.



MP2500.x at the oscillation limit



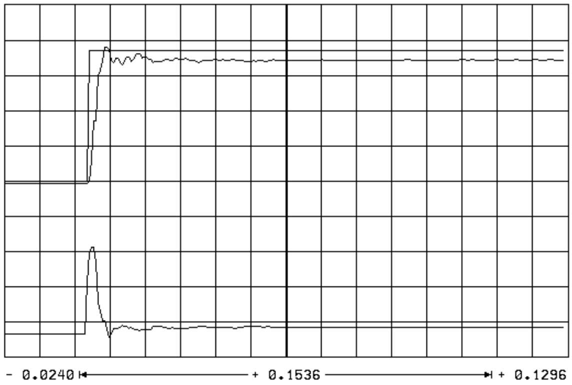
MP2500.x too small



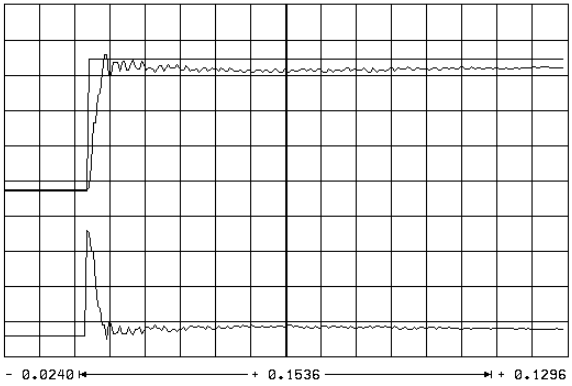
MP2500.x too large

▶ Input value for MP2500.x = <determined value> · 0.6

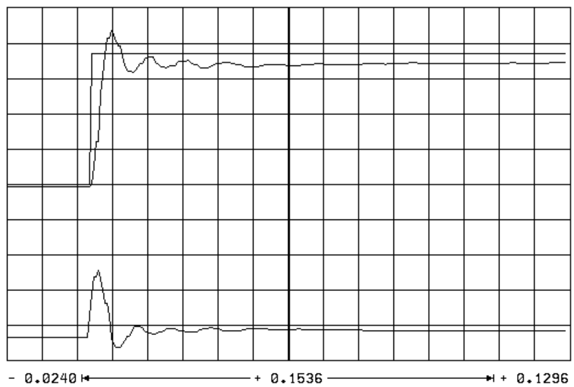
▶ Compensate high-frequency interference oscillations (> 400 Hz) with MP2530.x or MP2560.x.



MP2530.x at optimum setting



MP2530.x too small



MP2530.x too large

Warning

You can use MP2520.x to compensate low-frequency oscillation (< 100 Hz) on axes with mechanical problems.

However, HEIDENHAIN recommends that you avoid using MP2520.x if possible.

Do not use for axes with belt drive!

You can also compensate disturbance oscillations with the band-rejection filter:

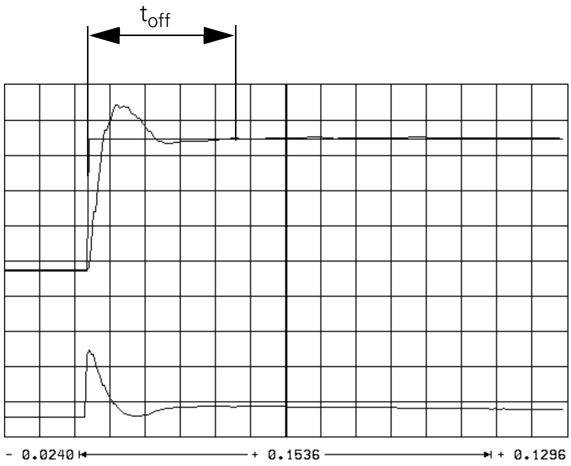
- Calculate the frequency of the oscillation and enter it in MP2550.x.
- Increase the band-rejection filter damping in MP2540.x until the interfering oscillation is minimized. Realistic input values: 3 to 9 [dB]

Note

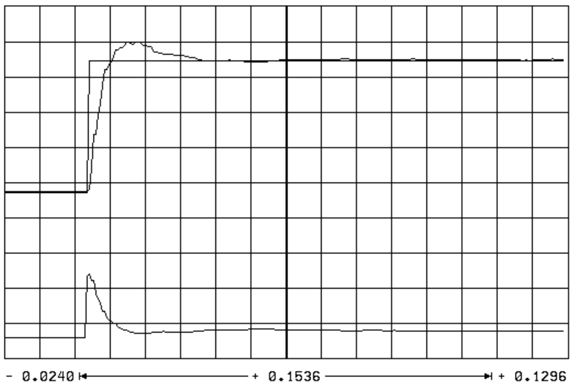
The compensation dampens the control loop. Try first to remove the mechanical causes of the disturbance oscillations.

To reduce the occurrence of disturbance oscillations, HEIDENHAIN recommends the use of motor couplings with a low tendency to oscillate (e.g. from the Rotex Company).

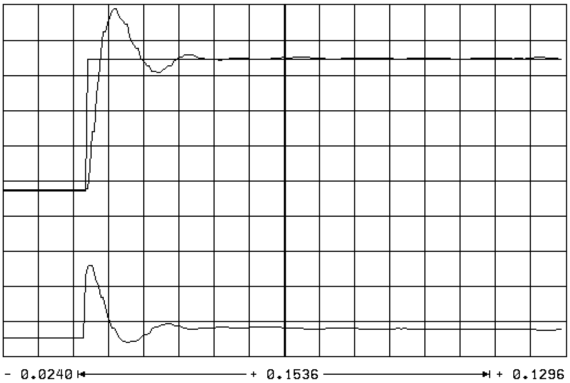
▶ Increase MP2510.x (I factor) until you see one overshoot followed by a slight undershoot and the settling time t_{off} is as small as possible (realistic value: 3 ms to 15 ms)



MP2510.x at optimum setting



MP2510.x too small



MP2510.x too large

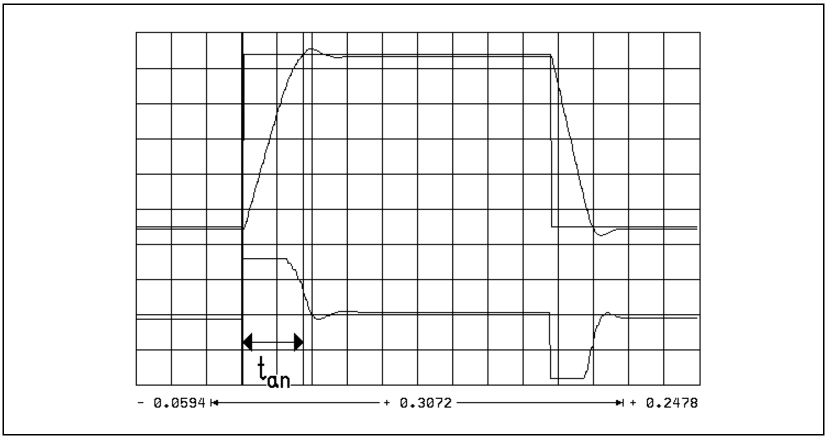
Determining the acceleration

- Clamp an object of maximum permissible weight on the machine table.
- Enter the rapid traverse as step height.
- During the step response, record the step response of the nominal velocity value V (NOM RPM), the actual speed value V (ACT RPM), and the nominal current value (I NOMINAL). It is permissible to limit the nominal current value I NOMINAL during acceleration.
- From the step response of the speed controller you determine the maximum possible acceleration (incl. 10% safety margin).

$$a = \frac{F_{max}}{t_{an} \cdot 66\,000}$$

a: Acceleration [m/s^2]
F_{max} : Maximum machining feed rate (MP1010.x) [mm/min]
t_{an} : Rise time [s]

- Enter the maximum possible acceleration in MP1060.x.



Check the counting direction

- On the oscilloscope, set TRIGGER to FREE RUN.
- To start recording:
- Change to MANUAL operating mode.
- Press the axis direction buttons.
- Check the counting direction on the display and if necessary, correct it with MP210.x.

Position Controller

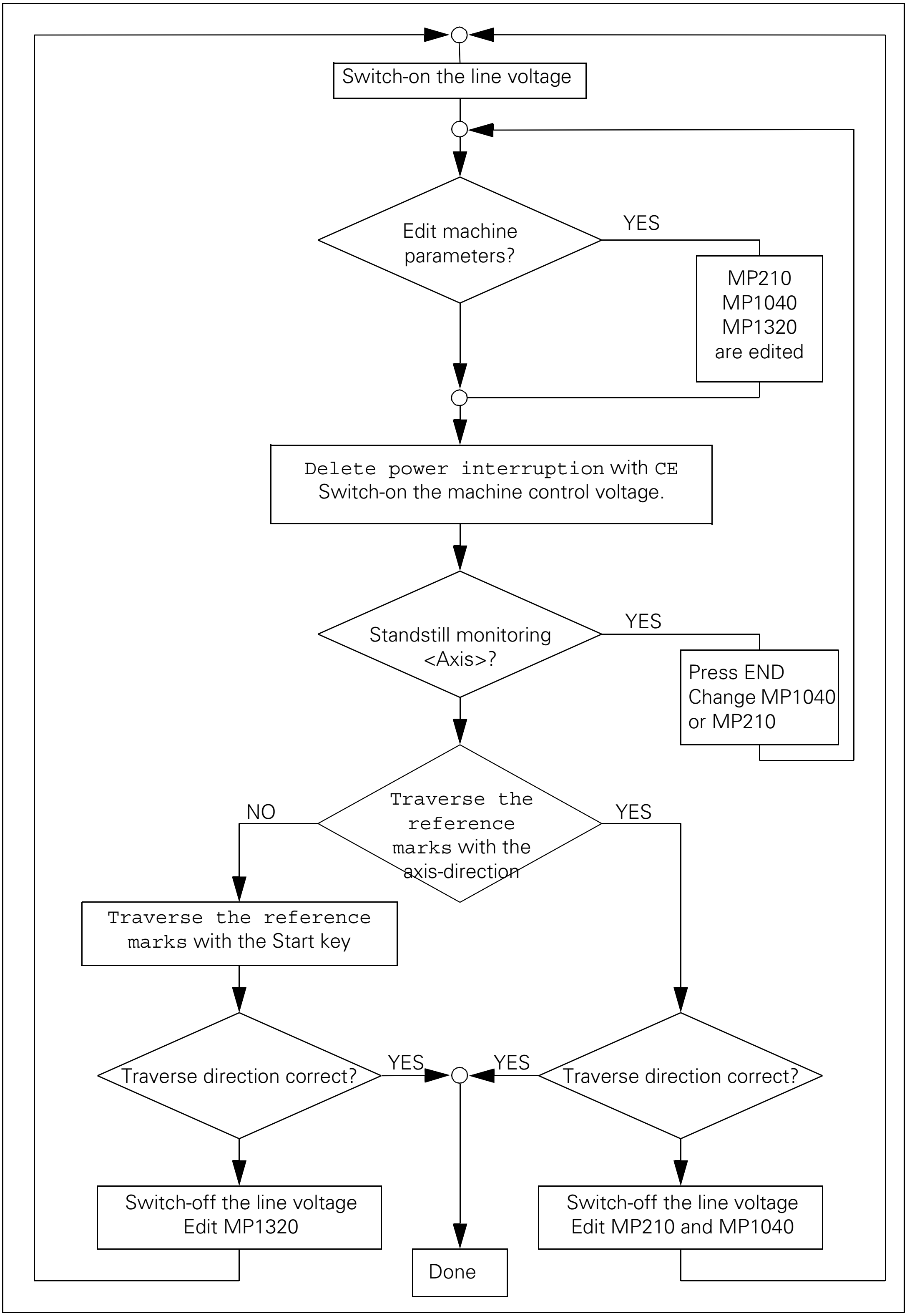
Adjusting the position control loop:

- Activate a PLC program that is adapted to the machine.
- Ensure that the position control loop is closed (W1038/W1040) and all inputs/outputs are properly operated.
- Optimize the position control loop in the following 12 steps:

If the position controller still oscillates after optimization, check the I factor (may be too high).

Step 1: Check the traversing direction (see flowchart)

- In MP1340.x, enter the sequence in which the reference points are to be traversed.


Switch-on the line voltage
Edit machine parameters?
YES
MP210
MP1040
MP1320
are edited
Delete power interruption with CE
Switch-on the machine control voltage.
Standstill monitoring <Axis>?
YES
Press END
Change MP1040
or MP210
Traverse the reference marks with the axis-direction
NO
YES
Traverse the reference marks with the Start key
Traverse direction correct?
YES
YES
Traverse direction correct?
Switch-off the line voltage
Edit MP1320
Done
Switch-off the line voltage
Edit MP210 and MP1040

Step 2: Set the traverse range

You can enter up to three traverse ranges.
See "Traverse Ranges" on page 6 – 19. Define the software limit switches as follows:

- In the MANUAL operating mode, press the MOD key to select the REF display. The position displays show the distance to the machine datum (MP960.x).
- With the axis direction buttons or the handwheel, move all axes in positive and negative direction until they almost reach the EMERGENCY STOP limit switches. Write down the displayed positions with algebraic sign.
- Enter the noted values in MP91x.x and MP92x.x.
- Press the MOD key and select the ACTL display.

Step 3: In MP1391 or MP1392, select the type of control

For control with velocity feedforward:

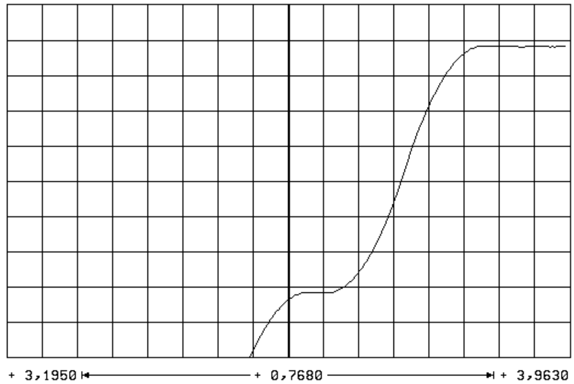
- Enter the temporary input values.

Machine parameters	Temporary input value
MP1391 or MP1392	Set to velocity feedforward control
MP1090.0	Enter a very small jerk, e.g. 1 (dependent on the machine)
MP1090.1	
MP1092	<greater than rapid traverse>
MP1095	0
MP1096	0
MP1099.0	5
MP1099.1	3
MP1396.x	1
MP1521.x	0

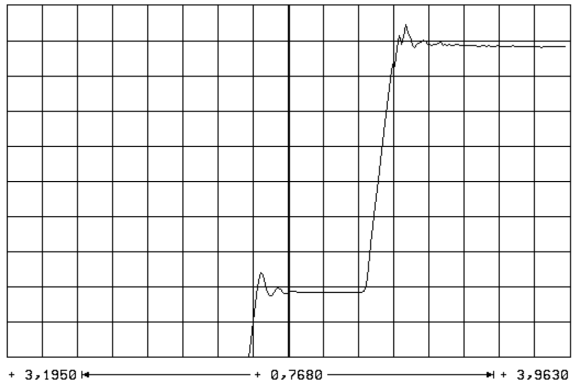
- Enter the following test program:

```
LBL 1
L X <maximum traverse>
R0 FMAX
LX0 FMAX
CALL LBL1 REP 100/100
```

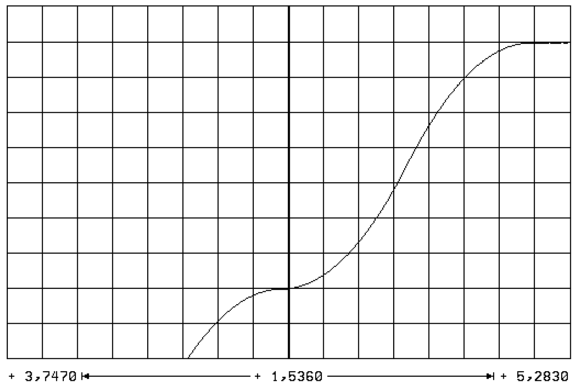
- Display the actual feed rate (v actual) with the integrated oscilloscope and, if necessary, also show the following error (lag).
- Start the test program with feed-rate override = 100%.
- In MP1090.0 increase the jerk until the overshoot just disappears.



MP1090.x at optimum setting

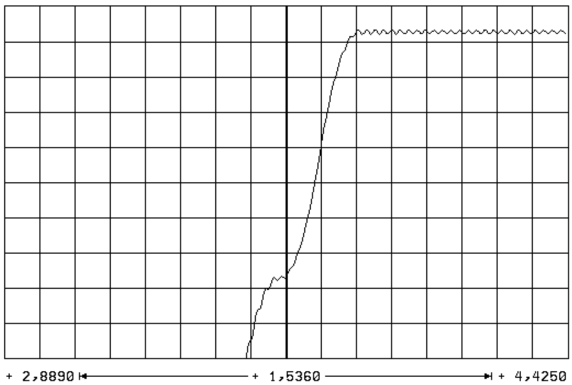


MP1090.x too large

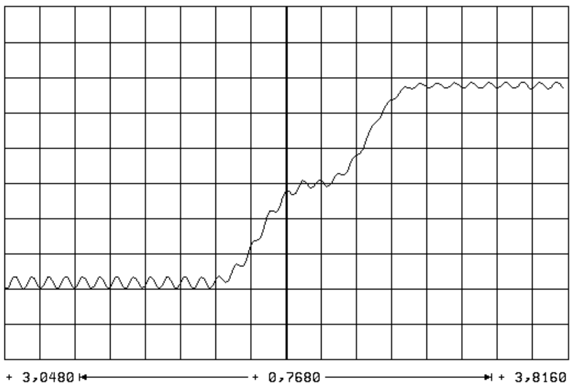


MP1090.x too small

- Enter the jerk determined from MP1090.0 in the axis-specific parameters MP1097.x and MP1098.x, and also in MP1086.x, MP1087.x and MP1089.x if required.
- Increase the k_v factor until the oscillation limit is reached.
- Calculate MP1510:
  MP1510.x = <determined value> · 0.6



Oscillation limit has been reached



k_v factor too large

Unlike in operation with following error, you can also enter the optimum k_v factor for interpolated axes. You can save a number of different k_v factors in the iTNC and activate them with M functions. See "The Control Loop" on page 6 – 113. MP1090.x applies to all axes. The worst axis determines the input value.

Procedure:

- Assume the axis specific values in MP1097.x and MP1098.x.
- Reduce the adjusted jerk (MP1090.0) depending on the mechanical design of the machine. Do not set the jerk lower than necessary, however, because this strongly reduces the dynamic performance.
  - If at optimized jerk the maximum acceleration is not reached during the acceleration phase, enter the maximum machining feed rate in MP1092. In this case, define a higher jerk for high feed rates (> MP1092) to increase acceleration at these feed rates.

To select the nominal position value filter:

- Run a test program of short line segments.
- Use the oscilloscope to record the following error for each axis.
- Determine for each axis the oscillations on the following error. If you cannot find any oscillations, increase the jerk for the test in order to excite oscillation in the axes. Remember after the test to reset the jerk for each axis to its original value.
- From the tables on Page 6–120, select the input values for MP1099.x or MP1094. Consider the lowest determined frequency and the desired damping at this frequency.
- With MP1095 you select the single or double filter. With MP1094 the HSC filter is switched on, and the single and double filters are switched off.
- Test the three filter settings using a test part made of short line segments.
  - Single filter
  - Double filter
  - HSC filter

Note

If you have selected the best nominal position value filter for your application, please note that your input value can be overwritten by the machine user through Cycle 32.
If you have switched off the nominal position value filter (MP1096 = 0), the machine user can also switch it on using Cycle 32.

Control with following error (servo lag):

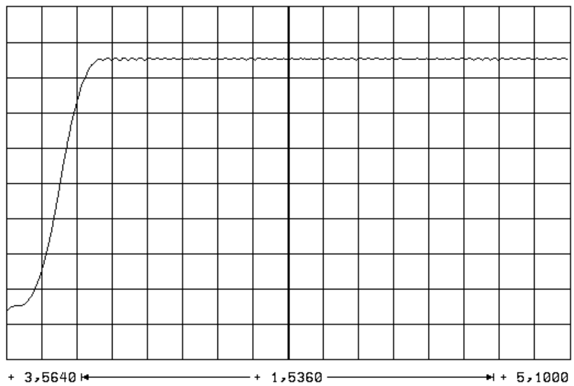
The adjusted maximum jerk works during operation with following error. MP1090 is not changed.

Procedure:

- Check the temporary input values for the machines parameters
- Specify the k_V factor for the machining feed rate:
- Enter the following test program:

```
LBL1
L X <maximum traverse> R0 F <machining feed rate>
L X0 R0 F <maximum machining feed rate>
CALL LBL1 REP 100/100
```

- Display the actual feed rate (v actual) with the internal oscilloscope.
- Start the test program with feed rate override = 100%.
- Increase the value in MP1810.x up to the oscillation limit.
- Calculate MP1810.x:
  MP1810.x = <determined value> · 0.6



MP1810.x at the oscillation limit

For axes that are interpolated with each other, the k_V factors must be equal. The axis with the smallest k_V factor defines the input value for all axes.

You can save a number of different k_V factors in the iTNC (MP1815.x) and activate them with M functions. See "The Control Loop" on page 6 – 113.

Procedure for defining a characteristic curve kink point:

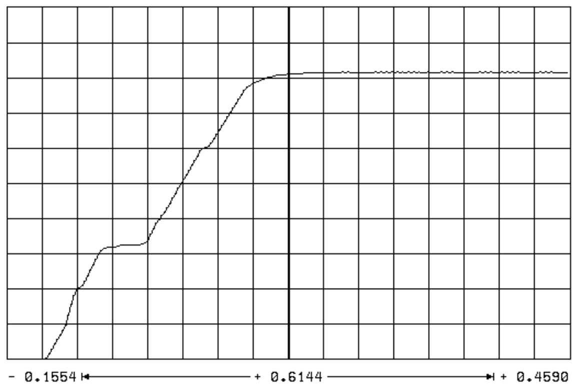
- k_V factor for rapid traverse (characteristic curve kink point):

$$\text{MP1830.x} = \frac{\text{Max. contouring feed rate} \cdot 100\ \%}{\text{Rapid traverse}}$$

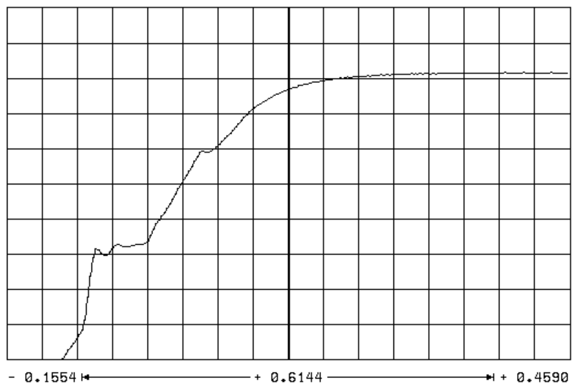
MP1820.x = 1

Set to operation with following error.

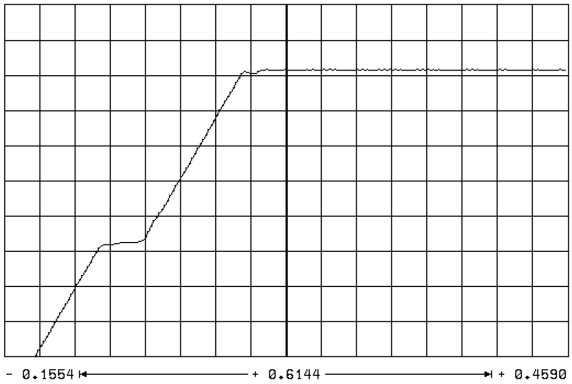
- Enter the following test program:
```
LBL2
L X <maximum traverse> R0 FMAX
L X0 R0 FMAX
CALL LBL1 REP 100/100
```
- Start the test program.
- Display the actual feed rate (v actual) with the internal oscilloscope:
  - If no oscillations are recognizable, no kink point is required.
  - If oscillations are visible, you must reduce MP1820.x until the oscillations have disappeared.



MP1820.x at optimum setting



MP1820.x too small



MP1820.x too large

Step 4: Switch-on the nominal position value filter

- In MP1096, enter a defined tolerance (e.g. 0.02 mm).

Step 5: Activate monitoring functions

> **Note**
>
> To ensure that the monitoring functions become effective at the right moment, you must enter meaningful values.

HEIDENHAIN recommends the following input values. You must change these values slightly to adapt them to the design of the machine.

MP	Temporary input value	Meaning
MP1030.x	0.01 mm	Positioning window
MP1110.x	2 · MP1030.x	Standstill monitoring
MP1140.x	0.03 [1000 rpm]	Movement monitoring
MP1144.x	0.5 mm	Motion monitor for position and speed
MP1410.x	0.5 mm	Position monitoring in operation with velocity feedforward control (erasable)
MP1420.x	2 mm	Position monitoring in operation with velocity feedforward control (EMERGENCY STOP)
MP1710.x	1.2 · following error in rapid traverse	Position monitoring in operation with following error (erasable)
MP1720.x	1.4 · following error in rapid traverse	Position monitoring in operation with following error (EMERGENCY STOP)

Step 6: Compensate the backlash

If the cause of the backlash is outside of the control loop:

- Enter the backlash in MP710.x.

If the cause of the backlash is inside of the control loop:

- Enter the following test program:

```
LBL 1
L X100 R0 F10
L X0
CALL LBL 1 REP 100/100
```

- Use the internal oscilloscope to record V ACTUAL and V (ACT RPM). At the reversal point the actual feed rate follows the actual shaft speed by the time delay *t*.
- Set the machine parameters:
  - MP750 = *t* · ΔV ACTUAL (keep in mind the units for *t* and ΔV ACTUAL)
  - MP752 = Approx. 20 ms (determined in test)

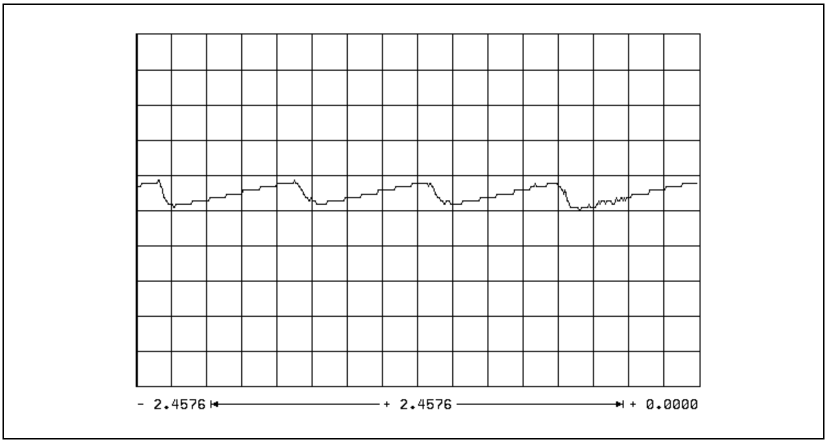
$$\Delta V\ ACTUAL = |V\ ACTUAL - V\ (ACT\ RPM)|$$

Step 7: Compensate the static (stick-slip) friction

- Enter the backlash, if any exists.
- Enter the following test program (static friction in the Y axis):

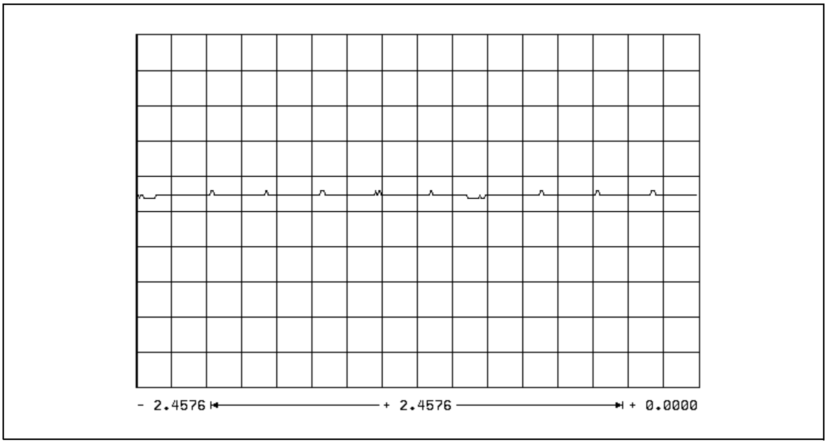
```
LBL 1
L X+400 IY+0.5 R0 F200
L X0 IY+0.5 R0
CALL LBL1 REP 100/20
```

- Set the machine parameters:
  - MP1511.x = 0
  - MP1512.x = 20
  - MP1513.x = 0
- With the integrated oscilloscope, display the following error in the Y axis (Y SDIFF).
- Start the program and adjust the feed-rate override so that the following error caused by static friction becomes visible.



- Increase the feed rate until the following error is no longer measurable.
- From the current contouring feed rate, calculate the feed rate specific to the Y axis and enter the value in MP1513.1.
- Adjust the feed rate until the following error is measurable again.

▶ Increase MP1511.x in increments of 10 000 until the following error is no longer measurable.



If the machine oscillates at a standstill:

▶ Decrease MP1512.x.

Step 8: Limit the integral factor of the shaft speed controller
Very high static friction can cause an axis to jerk loose and “jump” around the target position.

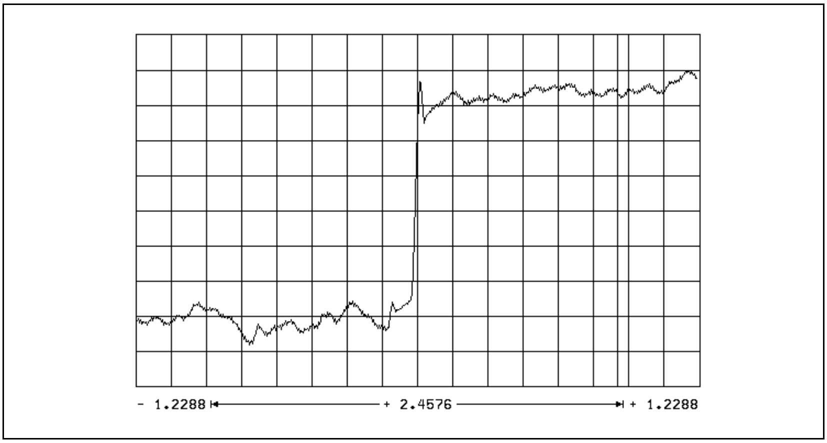
▶ Increase MP2512.x until the axis remains stationary.

Step 9: Adjust the holding moment

- Enter the following test program (static friction in axis Z):

```
LBL 1
L Z+2 R0 F50
L Z-2 R0 F50
CALL LBL 1/10
```

- Use the integrated oscilloscope to record the actual shaft speed (ACT RPM) and the nominal current value (I NOMINAL).
- Start the program.
- With the feed rate override knob, adjust the motor speed to ±10 rpm (MP1054.x).
- Determine the current (I NOMINAL) in both directions of rotation.



- Calculate MP2630.x:

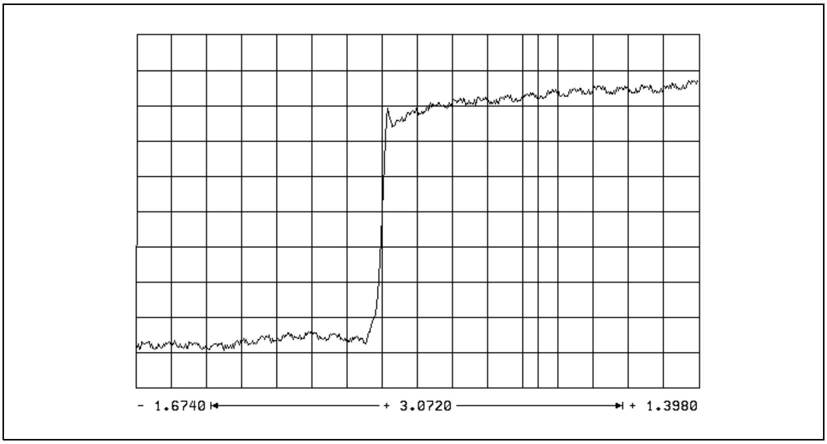
$$MP2630.x = \frac{I\ NOML_1 + I\ NOML_2}{2}$$

Step 10: Compensate the sliding friction

- Select operation with velocity feedforward control.
- Enter the following test program (sliding friction in the X axis):

```
LBL 1
L X+2 R0 F50
L X-2 R0 F50
CALL LBL 1/10
```

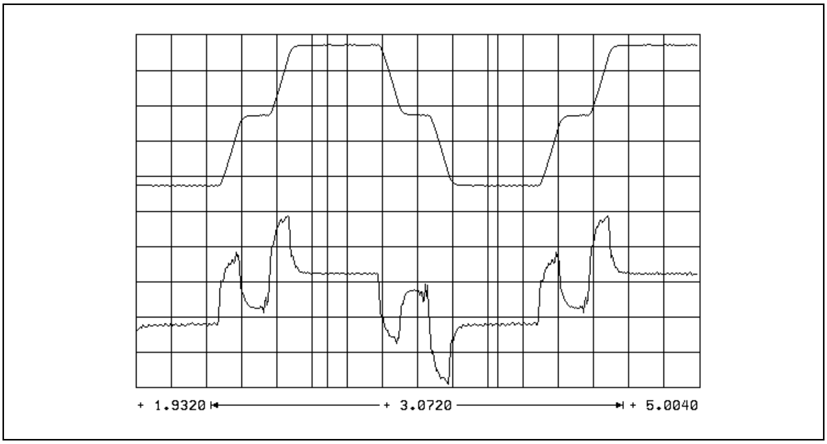
- Use the integrated oscilloscope to record the actual shaft speed (ACT RPM) and the nominal current value (I NOMINAL).
- Start the test program.
- With the feed rate override knob, adjust the motor speed to 10 rpm (MP1054.x).
- Determine the current (I NOMINAL) in both directions of rotation.



- Calculate MP2610.x:

$$MP2610.x = \frac{I\ NOML_1 + I\ NOML_2}{2}$$

- Change the test program so that the motor rotates at its rated speed.
- Restart the test program.
- Determine the current (I NOMINAL) for the rated shaft speed.



▶ Calculate MP2620.x:

$$MP2620.x = \frac{I\ NOML_1 - I\ NOML_2}{2}$$

In the event that the motor cannot be driven at the rated speed:

▶ Measure I NOMINAL at maximum speed (rapid traverse) and calculate the current at rated speed as follows:

$$MP2620.x = \frac{(I_{max} - MP2610.x) \cdot \text{<rated speed>}}{n_{max}} + MP2610.x$$

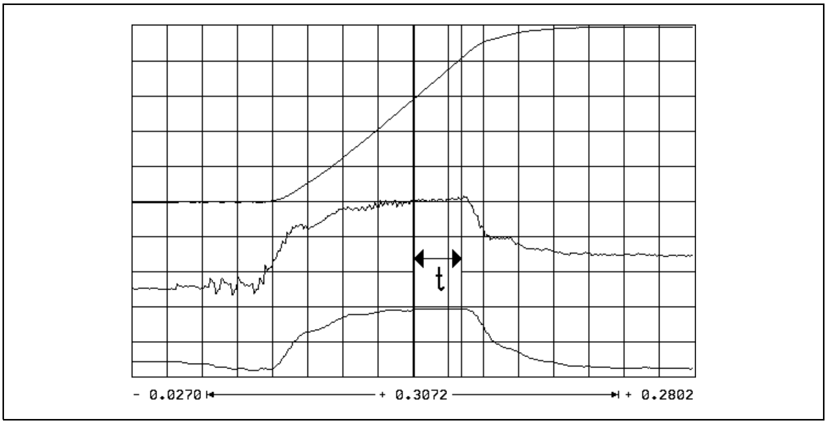
I_{nmax}: Current at rapid traverse

n_{max}: Shaft speed at rapid traverse

Step 11: Check the acceleration feedforward

- Select operation with velocity feedforward control.
- Enter the following test program:

```
LBL 1
L X+100 R0 F5000
L X-100 R0 F5000
CALL LBL 1/10
```



- Use the integrated oscilloscope to record the actual shaft speed (ACT RPM), the nominal current value (I NOMINAL), and the integral-action component of the nominal current value I (INT RPM).
- Start the test program.
- Adjust the speed with the feed-rate override knob so that I NOMINAL is not limited.
- Measure the gradient of the acceleration ramp in the part in which I (INT RPM) remains constant.
- Calculate MP2600.x:

$$MP2600.x = \frac{I\ (INT\ RPM)\ [A] \cdot t\ [s] \cdot 60\ [s/min] \cdot MP1054.x\ [mm]}{\Delta V\ (ACT\ RPM)\ [mm/min]}$$

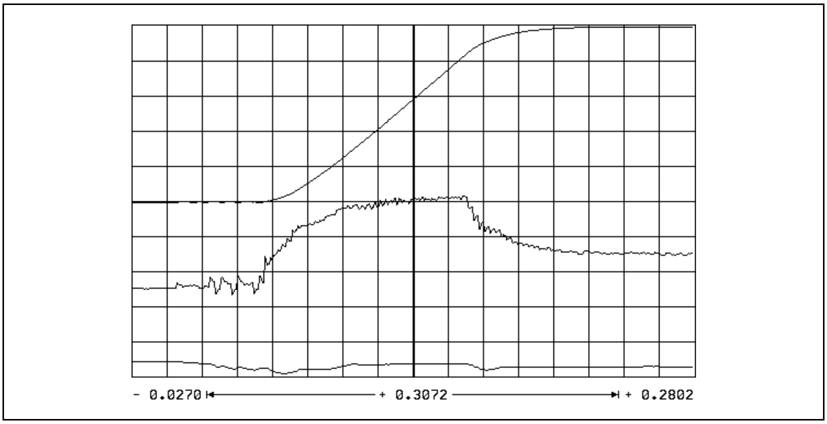
I (INT RPM) = Integral-action component of the nominal current value

t = Acceleration time in which I (INT RPM) remains constant

ΔV (ACT RPM) = Change of actual rpm during *t*

MP1054.x: Traverse distance per motor revolution

- Repeat this measurement to check the input value of MP2600.x. I (INT RPM) must have approached zero.



Step 12: Run the circular test

With the circular test you can check the exact input values for compensating sliding friction:

- Determine the radial acceleration:
  MP1070 = 0.7 · MP1060.x
  MP1060.x represents the smallest acceleration in the working plane.
- At mid-range feed rate (approx. 500 mm/min) check the parameter MP2610. At the optimum setting the reversal peaks are at a minimum.

At feed rates greater than approx. 6000 rpm the reversal peaks might point inward as a result of overcompensation:

- In this case, increase MP2612.x until the reversal peaks no longer point inward.

6.14.7 Commissioning the Digital Spindle

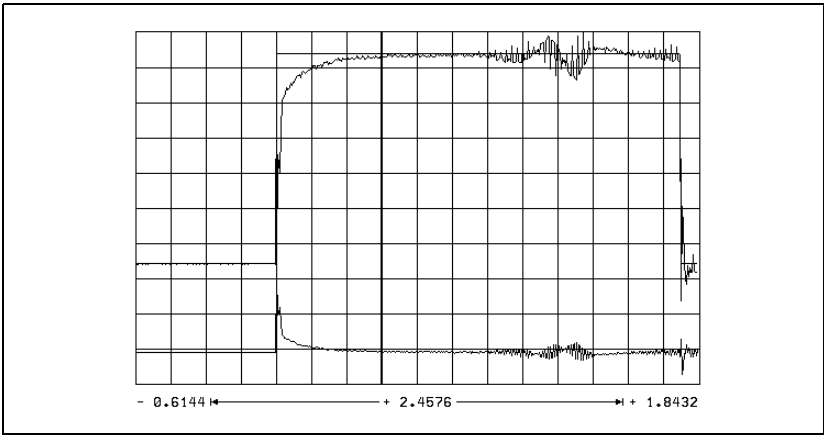
Current controller

Same procedure as for digital axes.

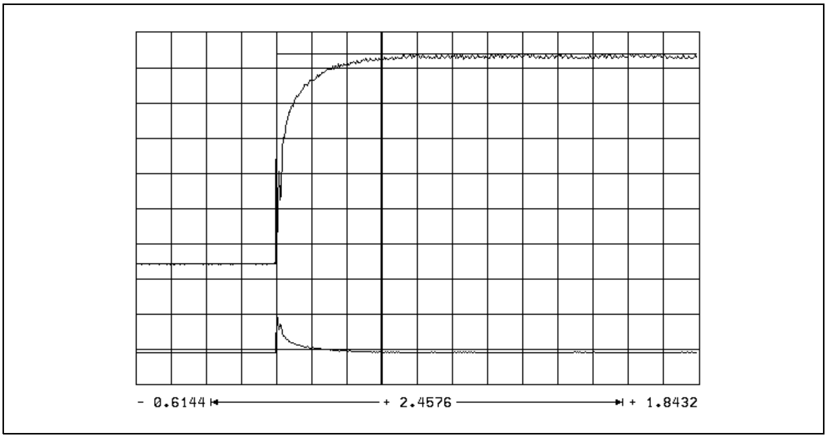
Speed controller

Define the step function:

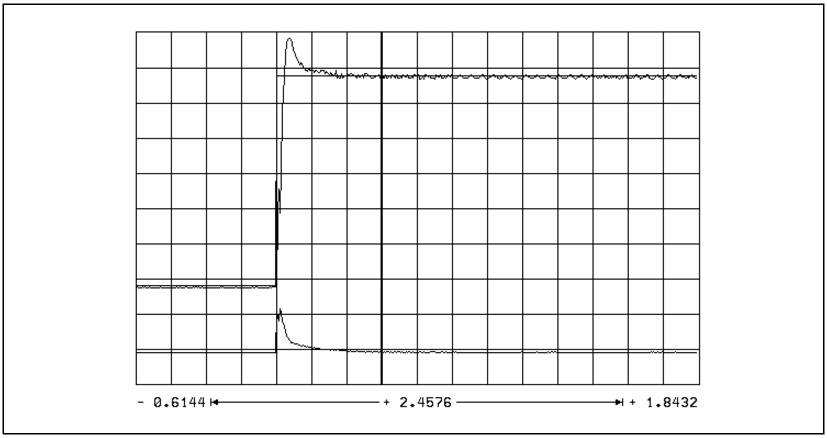
- In MP3411.x, enter the maximum acceleration and start the step by switching the spindle on.
- Activate a spindle speed from the highest gear range.
- With the integrated oscilloscope, record the nominal velocity value V (NOM RPM), the actual speed value V (ACT RPM), and the nominal current value (I NOMINAL).
- Output a step by activating the spindle-on function (M03/M04).
- Choose the height of the step function for a very low speed so as not to overload the speed controller, i.e. so that I NOMINAL is not limited.
- Increase the P factor (MP2500.x) until the system oscillates or no change is visible. To edit machine parameters, press the MP EDIT soft key in the Setup menu.



- Calculate MP2500.x: MP2500.x = MP2500.x · 0.6

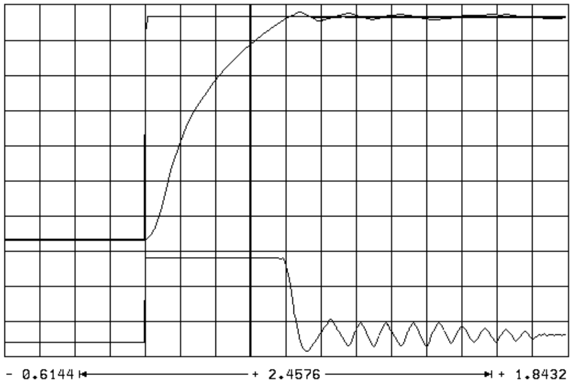


▶ Increase the I factor (MP2510.x) until you see one overshoot followed by a slight undershoot.

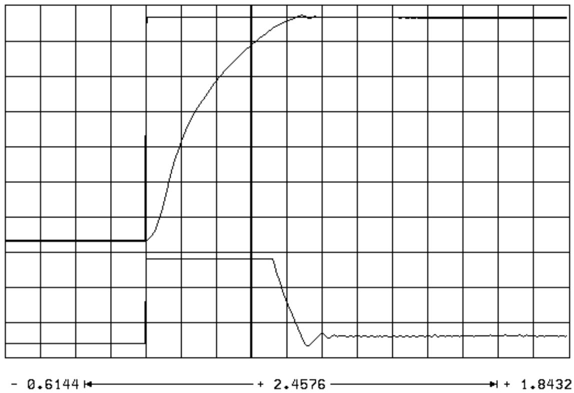


▶ Output the step with maximum shaft speed. I NOMINAL is within the limitation during acceleration. I NOMINAL must not oscillate after reaching the maximum speed. If I NOMINAL oscillates:

- Reduce MP2500.x and MP2510.x evenly until the overshoots are minimized.



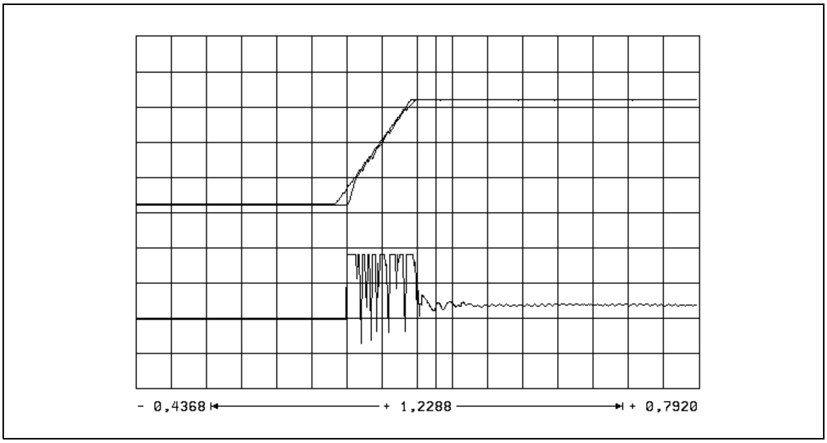
I NOMINAL oscillating



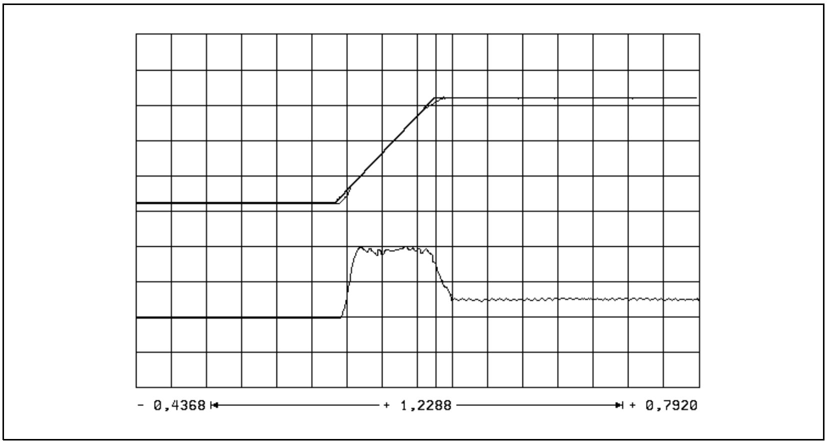
Only one overshoot

Optimize the acceleration:

- Optimize the acceleration individually for each gear range.
- Choose a ramp gradient at which the motor almost reaches the electrical current limit, and set it with MP3411.x.



- In MP3412.0, enter a factor for MP3411.x that becomes effective in the braking ramp with M05. It is the electrical current limit that is braked.



In the TAPPING and SPINDLE ORIENTATION modes, I NOMINAL must not reach the limit for acceleration:

- In MP3412.x, enter a factor for MP3411.x for these operating modes.
- With MP3415.x, specify an individual overshoot behavior for every spindle operating mode. Adapt the nominal value trace to the actual trace.

Checking the direction of rotation

You can check the direction of rotation of the spindle when M03 is output. If the spindle does not rotate in clockwise direction:

- Modify MP3130.

Position controller

The position control loop of the spindle is closed only during the spindle orientation:

- Close the position control loop of the spindle. See "Oriented spindle stop" on page 6 – 209.
  - If the error message "Nominal speed value S too high" appears, you must modify MP3140.
- Optimize the k_v factor (MP3440.x for each gear range.
  A TOOL CALL must be run to transfer the modified gear-specific MPs.

6.14.8 Commissioning an Analog Axis

Temporary input values

▶ Enter the following temporary input values when you begin

MP	Temporary input value	Meaning
MP1030.x	0.01	Positioning window
MP1090.x	1	Maximum permissible jerk on the tool path
MP1092	<Maximum rapid traverse>	Feed rate threshold from which MP1090.1 becomes effective
MP1110.x	2.0	Standstill monitoring
MP1140.x	10	Movement monitoring
MP1410.x	0.5	Position monitoring in operation with velocity feedforward control (erasable)
MP1420.x	2	Position monitoring in operation with velocity feedforward control (EMERGENCY STOP)
MP1510.x	1	k_V factor for velocity feedforward control
MP1710.x	50	Position monitoring in operation with following error (erasable)
MP1720.x	50	Position monitoring in operation with following error (EMERGENCY STOP)
MP1810.x	1	k_V factor for control with following error
MP1820.x	1	Multiplier for the k_V factor
MP1830.x	100	Characteristic curve kink point

Adjusting the servo amplifier

Note

For analog axes, you must adjust the servo amplifier before you optimize the position controller.

Procedure:

▶ Disconnect the nominal-value connection between the servo amplifier and the MC 422.

▶ Short-circuit the nominal value input on the servo amplifier.
The input must have a 0 V voltage.

▶ Activate control enabling at the servo amplifier.

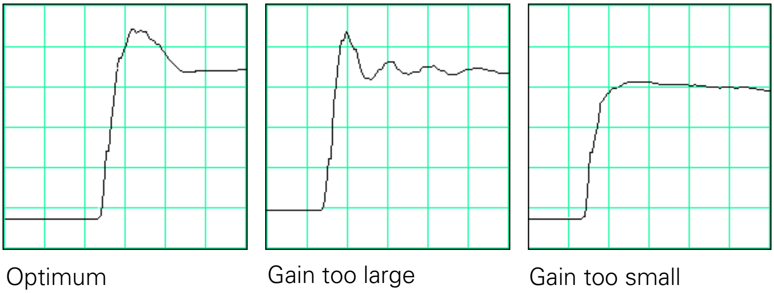
▶ Connect the supply voltage to the servo amplifier.

▶ Perform a coarse offset adjustment:

- If the axis moves in spite of the short-circuited nominal value input, you must adjust the offset potentiometer until the axis stops moving.

▶ Remove the jumper at the nominal value input and establish a nominal-value connection to the MC 422.

- Perform a coarse velocity adjustment:
  - Set MP1010.x (rapid traverse) and MP1050.x (analog voltage at rapid traverse).
  - With the internal oscilloscope functions, output the nominal value step at the height for rapid traverse.
  - Record VOLT.ANALOG and check the voltage.
  - Use a tachometer to measure the rotational speed of the motor and a tacho-potentiometer at the servo amplifier to adjust the nominal speed for rapid traverse.
  - Connect an oscilloscope to the tachometer of the motor.
  - Test the step response on the tachometer during the step output.
- Adjust the proportional (P) component and the integral-action (I) component of the speed controller at the servo amplifier.



Determining the acceleration

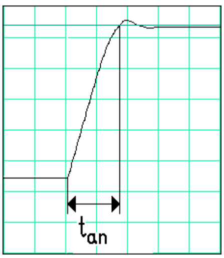
After adjusting the servo amplifier, you can determine from the step response the maximum possible acceleration:

$$a = \frac{F_{max}}{t_{an} \cdot 60\,000}$$

a: Acceleration [m/s^2]

F_{max}: Maximum machining feed rate (MP1010.x) [mm/min]

t_{an}: Rise time [s]



- Enter the maximum possible acceleration in MP1060.x.

Position controller

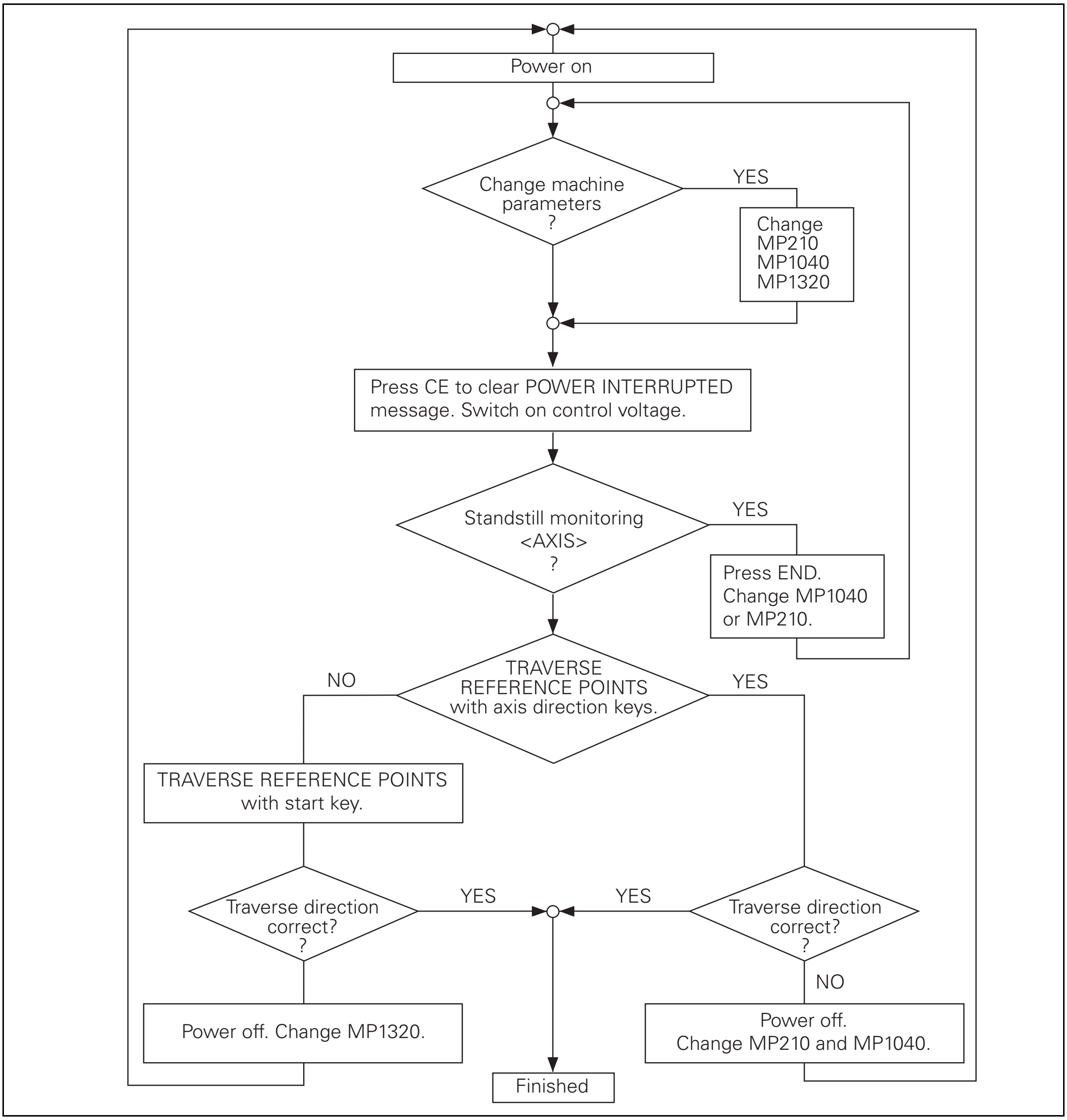
Please note:

> **Note**
>
> For analog axes, you must adjust the servo amplifier before you optimize the position controller.

Adjusting the position control loop:

- Activate a PLC program that is adapted to the machine.
- Ensure that the position control loop is closed (W1038/W1040) and all inputs/outputs are properly operated.
- To optimize the position control loop take the following steps:

Step 1: Check the direction of traverse
(see flowchart)



Step 2: Set the traverse range
Same procedure as for digital axes.

Step 3: Specify the type of control
For control with following error, same procedure as for digital axes.

For control with velocity feedforward control, same procedure as for digital axes.

Step 4: Perform an offset adjustment
On the iTNC: See "The Control Loop" on page 6 – 113.

Step 5: Activate monitoring functions

- Enter the following temporary input values when you begin: See "Commissioning of Digital Axes" on page 6 – 254

Step 6: Compensate the backlash
Same procedure as for digital axes.

Step 7: Compensate the static (stick-slip) friction
Same procedure as for digital axes.

6.14.9 Commissioning the Analog Spindle

Adjusting the servo amplifier
Same procedure as for analog axes.

Acceleration
Same procedure as for digital spindle. You measure the signals directly at the servo amplifier with an external oscilloscope.

Direction of rotation
Same procedure as for digital spindle.

Position controller
Same procedure as for digital spindle.

7 CC 424 Controller Unit

7.1 Differences between the CC 424 and CC 422

Function	CC 424	CC 422
Hardware	Position encoder inputs X201 to X206 and X207 to X210 on the CC 424	No position encoder inputs on the CC 422; they are on the MC 422
Assignment of speed encoder inputs to the PWM outputs	Fixed assignment, MP112.x omitted	Variable assignment via MP112.x
Stick-slip friction compensation	Feed-rate independent; MP2610.x same meaning as previously (effective values, readjustment necessary), MP2612 has new meaning MP2614.x is new	Feed-rate dependent; MP2610.x and MP2612.x (peak values)
PWM frequency	5000 Hz (temporarily fixed for all control loops)	Can be set via MP2180.x
Single-speed/double-speed	Single-speed: X51, X52, X53, X54 Double-speed: X55, X56, X57, X58, X59, X60	–
Control-loop cycle times (at 5000-Hz PWM frequency) (position/velocity/current)	Single-speed: 200 µs/200 µs/100 µs Double-speed: 200 µs/100 µs/100 µs (with position encoder) 100 µs/100 µs/100 µs (without position encoder)	1.8 ms/0.6 ms/100 µs (at 5000-Hz PWM frequency)
Filter in the speed control loop	MP2530.x, MP2540.x, MP2550.x and MP2560.x omitted, New machine parameters MP2542.x to MP2546.x, MP2552.x to MP2556.x, MP2562.x to MP2566.x, MP2572.x to MP2576.x, MP2560.x has new meaning	Filter setting via MP2530.x, MP2540.x, MP2550.x and MP2560.x
Display in internal oscilloscope and in TNCopt	Effective values	Peak values
MP115.x, MP116.x	When using an MC 422 without position encoder inputs, MP115.x is omitted. Otherwise MP115.x applies to the position encoder inputs on the MC 422; MP116.x applies to the position encoder inputs on the CC 424	MP115.x applies to the position encoder inputs on the MC 422

Function	CC 424	CC 422
MP2220.x	Bit 4: Monitoring for excessive temperature Bit 5: Monitoring for insufficient temperature Bit 6: Reserved Bit 7: Monitoring of encoder input frequency Bit 8: Adjust mechanical offset by gradually increasing the k_V factor	Bits 4, 5, 6, 7 and 8 are without function
MP2250.x, MP2252.x	Determining the field angle for nonaligned encoders	–
MP7602	PLC cycle time [ms]	–
MP7600.0	MP7600.x omitted, path interpolation fixed at 3 ms (does not influence the position controller cycle)	Factor for position controller cycle time; factor x 0.6 [ms]

The following functions are not yet supported for the CC 424:

- Velocity semifeedforward control (MP1516.x)
- Static friction compensation (MP1511.x, MP1512.x)
- Multiplication factor for k_V factor and kink point (MP1820.x, MP1830.x)
- Master-slave torque control
- Backlash compensation (cause within the controlled system)

7.2 Connecting the Encoders

7.2.1 General Information

HEIDENHAIN contouring controls are designed for use with incremental linear and angular encoders as measuring systems. The encoder signals are interpolated 1024-fold.
Encoders with one reference mark or distance-coded reference marks and with EnDat interface are permissible.

Please use only HEIDENHAIN encoder cables, connectors and couplings.

7.2.2 Position Encoders

Incremental position encoders with 1V $_{PP}$ signals and absolute encoders with EnDat interface can be connected to the CC 424.

- Set the encoder signal with MP116.0
- With MP116.2, you set the maximum input frequency.

Note

The incremental track data must be entered for the corresponding position encoder inputs for encoders with EnDat interfaces.

MP116.0 **Position encoder input 1 V_{PP} or 11 μA_{PP}**
Format: %xxxxxxxxxxx
Input: Bit 0 to bit 9: Linear encoder inputs X201 to X210
Bit 10: No function
0: 1 V_{PP}
1: 11 μA_{PP}

MP116.1 **Reserved**
Format: %xxxxxxxxxxx
Input: Enter %00000000000

MP116.2 **Input frequency of the linear encoder inputs**
Format: %xxxxxxxxxxx
Input: Bit 0 to bit 9: Linear encoder inputs X201 to X210
Bit 10: No function
For 1 V_{PP}: 0: 33 kHz
1: 350 kHz
For 11 μA_{PP}: 0: 33 kHz
1: 150 kHz

7.2.3 Speed Encoders

Incremental position encoders with 1V $_{PP}$ signals and absolute encoders with EnDat interface can be connected to the CC 424.

7.3 Relationship between Speed Input and PWM Output

On the CC 424 there is a **fixed assignment of speed encoder input to PWM output.** MP112.x is omitted for this reason (special case: MP113.x). The selection of the encoder inputs and PWM outputs is only via MP120.x/MP121.x.

Drive control board	PWM output (MP120.x/MP121.x)	Speed encoder input
1	X51	X15
1	X52	X16
1	X53	X17
1	X54	X18
1	X55	X19
1	X56	X20
2	X57	X80
2	X58	X81
2	X59	X82
2	X60	X83

Special case: MP113.x

MP113.x is used to switch the speed encoder inputs for the operation of a second spindle.
If only one spindle is used, MP113.x = 0, and the assignment from the above table is valid.

If, for example, two spindle motors are driven with one PWM output (and the same power module) and the power can be switched over through a contactor, the speed encoder input can be selected with MP113.x.

PWM output for the spindle	Speed encoder input	MP113.x input value
X51	X15 or X17	0, 15 or 17
X52	X16 or X18	0, 16 or 18
X53	X15 or X17	15 or 0, 17
X54	X16 or X18	16 or 0, 18

The error message **`C2A0 Encoder input <axis>`** appears if an invalid entry is given for MP113.x.

7.4 Relationship between PWM Output and Position Input

The position encoder inputs for digital control loops are no longer on the MC 422, but on the CC 424. There is an MC 422 (Id.-Nr. 369 947-xx) without position encoder inputs.

The position encoder inputs can be assigned in any order on the drive control board. Use MP110.x/MP111.x for this.
The position encoder inputs X201 to X206 can be assigned as desired to the PWM outputs X51 to X56, and the position encoder inputs X207 to X210 to the PWM outputs X57 to X60.

Drive control board	Position encoder input (MP110.x/MP111.x)
1	X201
1	X202
1	X203
1	X204
1	X205
1	X206
2	X207
2	X208
2	X209
2	X210

7.5 Single-Speed, Double-Speed, PWM Frequencies

The CC 424 differentiates between single-speed control loops (S) and double-speed control loops (D). Double speed control loops operate with shorter controller cycles.
With single-speed control loops, one DSP is assigned to two control loops.
With double-speed control loops, one DSP is assigned to one control loop.
When installing modular inverter systems, make sure that power modules that must operate with double-speed control loops are aligned on the left, and power modules that only require single-speed control loops are aligned on the right (due to the alignment of the PWM outputs on the CC 424).

Single-speed control loops are used for:

- Spindles
- Conventional axes

Double-speed control loops are used for:

- Linear motors
- Torque motors
- High-frequency spindles
- "Axes that are difficult to control"

Drive control board	PWM output (MP120.x/MP121.x)	Control loop (S = Single-speed, D = Double-speed)	Cycle time (for 5-kHz PWM frequency)		
			Position controller	Speed controller	Current controller
1	X51	S	200	200	100
1	X52	S	200	200	100
1	X53	S	200	200	100
1	X54	S	200	200	100
1	X55	D	200	100	100
1	X56	D	200	100	100
2	X57	D	200	100	100
2	X58	D	200	100	100
2	X59	D	200	100	100
2	X60	D	200	100	100

Note

For all axes, only the **PWM frequency** of **5 kHz** is supported at present.

7.6 PLC Cycle Time

MP7600.0 has no meaning for the CC 424. Therefore, MP7600.x is omitted. The position controller cycle time depends on the PWM frequency, and is $T_{position\ controller} = 1 : f_{PWM}$.

▶ Enter the PLC cycle time in ms in MP7602.

MP7602 **PLC cycle time**
Input: 0 to 60 [ms]
0 to 10: 10.8 ms

7.7 Monitoring Functions

The KTY temperature sensor of the motors is monitored by the control for excessive and insufficient temperatures. If the KTY is not to be evaluated (e.g. because the temperature sensor is not doubly isolated), this function must be deactivated with MP2220.x bit 4 = 1.

The CC 424 monitors the input frequency of the speed encoders. If this monitoring leads to problems (e.g. unjustified responses), it can be deactivated with MP2220.x bit 7 = 1. The following error messages can appear:

- Speed encoder: **8860 Input frequency from speed encoder <axis>**
- Position encoder: **8870 Input frequency from position encoder <axis>**

Position encoders are not used with linear or torque motors. If such an axis is removed from the closed-loop control and later reintroduced, a mechanical offset can occur. This offset is not fixed "in one blow," but instead is adjusted by gradually raising the k_V factor from 0 to the original value. This function is deactivated with MP2220 bit 8 = 1.

MP2220.x **Monitoring functions**
Input: Bit 4 – Monitoring for excessive temperature
0: Active
1: Inactive
Bit 5 – Monitoring for insufficient temperature
0: Active
1: Inactive
Bit 6 – Reserved
Bit 7– Monitoring of encoder input frequency
0: Active
1: Inactive
Bit 8 – Adjust mechanical offset by gradually increasing the k_V factor
0: Active
1: Inactive

7.8 Speed Controller Filters

With the CC 424, the manipulated variable of the speed controller (= nominal current) can be influenced through up to five filters. These filters are multifunctional filters, which means that the filter type of each individual filter order can be selected as desired. They are also effective for the spindle(s).

Two different filter types are available for selection:

- PT2 low-pass filter
- Band-rejection filter

	Filter 1	**Filter 2**	**Filter 3**	**Filter 4**	**Filter 5**
Filter selection 0 = Filter deactivated 1 = PT2 low-pass filter 2 = band-rejection filter	MP2562.x	MP2563.x	MP2564.x	MP2565.x	MP2566.x
Damping of band-rejection filter [dB]	MP2542.x	MP2543.x	MP2544.x	MP2545.x	MP2546.x
Center frequency of band-rejection filter / base frequency of PT2 [Hz]	MP2552.x	MP2553.x	MP2554.x	MP2555.x	MP2556.x
Bandwidth of band-rejection filter [Hz]	MP2572.x	MP2573.x	MP2574.x	MP2575.x	MP2576.x

The filters can be used in any combination, i.e. even if the first filter (MP2542.0, MP2552.0, MP2562.0, MP2572.0) is deactivated, the second filter (MP2543.1, MP2553.2, MP2563.3, MP2573.4), for example, can be used.

The parameters MP2540.x and MP2550.x (band-rejection filter) have no meaning for the CC 424, and are therefore omitted.
The function of MP2560.x (CC 422: low-pass filter) has changed:
If a low-pass filter is used with the CC 424, the filter order of the low-pass filter can be set in MP2560.x Normally MP2560.x = 0. Only if there is too much current noise (visible on the oscilloscope with **`I noml`** or **`Utilization`**) should MP2560.x = 10 to 20.

See "Adjustment of the Speed Controller" on page 7 – 34 for adjustment of the filters.

MP2542.x **Damping the band-rejection filter for filter 1**
Input: 0 to 99 [dB]

MP2543.x **Damping the band-rejection filter for filter 2**
Input: 0 to 99 [dB]

MP2544.x **Damping the band-rejection filter for filter 3**
Input: 0 to 99 [dB]

MP2545.x **Damping the band-rejection filter for filter 4**
Input: 0 to 99 [dB]

MP2546.x **Damping the band-rejection filter for filter 5**
Input: 0 to 99 [dB]

MP2552.x **Center frequency of the band-rejection filter for filter 1**
Input: 0 to 30 000 [Hz]

MP2553.x **Center frequency of the band-rejection filter for filter 2**
Input: 0 to 30 000 [Hz]

MP2554.x **Center frequency of the band-rejection filter for filter 3**
Input: 0 to 30 000 [Hz]

MP2555.x **Center frequency of the band-rejection filter for filter 4**
Input: 0 to 30 000 [Hz]

MP2556.x **Center frequency of the band-rejection filter for filter 5**
Input: 0 to 30 000 [Hz]

MP2560.x **Filter order of the low-pass filter**
Input: 0 to 20
Recommended input value: 0
Recommended input value if much current noise from high-frequency spindles: 10 to 20

MP2562.x **Filter type for filter 1**
Input: 0: No filter
1: PT2 low-pass filter
2: Band-rejection filter

MP2563.x **Filter type for filter 2**
Input: 0: No filter
1: PT2 low-pass filter
2: Band-rejection filter

MP2564.x **Filter type for filter 3**
Input: 0: No filter
1: PT2 low-pass filter
2: Band-rejection filter

MP2565.x **Filter type for filter 4**
Input: 0: No filter
1: PT2 low-pass filter
2: Band-rejection filter

MP2566.x **Filter type for filter 5**
Input: 0: No filter
1: PT2 low-pass filter
2: Band-rejection filter

MP2572.x **Bandwidth of the band-rejection filter for filter 1**
Input: 0 to 30 000 [Hz]

MP2573.x **Bandwidth of the band-rejection filter for filter 2**
Input: 0 to 30 000 [Hz]

MP2574.x **Bandwidth of the band-rejection filter for filter 3**
Input: 0 to 30 000 [Hz]

MP2575.x **Bandwidth of the band-rejection filter for filter 4**
Input: 0 to 30 000 [Hz]

MP2576.x **Bandwidth of the band-rejection filter for filter 5**
Input: 0 to 30 000 [Hz]

7.9 Stick-Slip Friction Compensation at Quadrant Transitions

Stick-slip friction compensation for the CC 424 has been improved in comparison to stick-slip friction compensation for the CC 422.
With the CC 422, the quadrant transition is only influenced by MP2612.x after the zero crossover of the speed. With the CC 424, the compensation already begins before the zero crossover of the speed.

Wit the CC 424, the parameters MP2612.x and MP2614.x now function with respect to distance rather than time (unit: [mm]).
This makes it possible to compensate quadrant transitions independently from velocity, acceleration, and diameter.

Adjustment of the stick-slip friction compensation with TNCopt is in development.

MP2610.x **Friction compensation at low motor speed**
Input: 0 to 30.0000 [A] (effective value)
0: No friction compensation

MP2612.x **Distance before the reversal point from which a reduction of the current from MP2610.x is to go into effect**
Input: 0 to 1.000 [mm] or [°]
0: No friction compensation
0.1: Typical input value

MP2614.x **Distance from the reversal point from which the current from MP2610.x is to go into effect again**
Input: 0 to 1.000 [mm] or [°]
0: Friction compensation same as CC 424
0.1: Typical input value

7.10 Field Orientation

If a linear, torque or synchronous motor is used with an incremental encoder without a Z1 track or an absolute encoder with EnDat interface, there is no association between the encoder and the rotor magnets. This applies to the following motors:

- All linear motors (e.g. with LB or LC)
- All torque motors (e.g. with RON or RCN)
- Special synchronous motors (e.g. synchronous spindles with ERM)

The iTNC 530 uses the Field Orientation function to automatically determine the association between the encoder and rotor magnets (field angle), and stores this information internally.

Note

The field angle can be determined only if the current controller is already adjusted!

The field angle is to be found for the following motors:

- Linear motor with absolute encoder with EnDat interface (SYS = 3)
- Synchronous or torque motor with nonaligned rotary encoder with EnDat interface (SYS = 5)
- Synchronous or torque motor with incremental rotary encoder without Z1 track (SYS = 6); one reference mark per revolution
- Synchronous or torque motor with incremental rotary encoder with distance-coded reference marks (SYS = 7)
- Linear motor with incremental linear encoder with distance-coded reference marks (SYS = 8)

Absolute encoder with EnDat interface	Incremental encoders
As soon as the absolute position of the encoder has been read, the absolute position and determined field angle are associated. The field angle is associated with the zero position of the encoder.	After switching on the drive, the motor orients itself (rough orientation; the message **`Finding the field angle`** appears). The drive is ready for operation after this procedure. The field angle is determined and associated as soon as the reference mark(s) is/are traversed during the first motor motion.

Danger

If the speed encoder is exchanged, the Field Orientation function must be rerun.

7.10.1 Possibilities for Determining the Field Angle

There are two possibilities for determining the field angle:

- The field angle is determined automatically when the drive is switched on, without any motion of the motor. The method of determination is set in MP2250.x. The field angle is stored after it has been determined. This field angle is used when the motor is switched on again. The **FIELD ORIENT.** soft key has no function.
- By pressing the **FIELD ORIENT.** soft key once while the motor is being commissioned. The soft key appears in the **Commissioning Current Controller** operating mode. After pressing it, the motor moves. The field angle is determined and stored during this motion. This field angle is used when the motor is switched on again. A plausibility test is run during the field angle determination.

Warning

This method cannot be used for hanging axes (with 100% weight compensation), since the brakes are not applied and the monitoring functions are deactivated!

▶ Select the method for field angle determination in MP2254.x.

HEIDENHAIN recommends using MP2254.x = 2 when commissioning new drive systems (such as machine prototypes), because the plausibility test will be run. After successful commissioning, MP2254.x = 0 can be used to save time (such as for series production of the machine).

MP2254.x	**Determining the field angle**
Input:	0: Field angle is determined during operation; soft key has no function (without plausibility test) 2: Only CC 424: Field angle is determined via soft key; motor motion is permitted (with plausibility test)

Note

For synchronous spindles, the field angle should be determined via the **FIELD ORIENT.** soft key (MP2254.x = 2), since this is a more exact determination.

Plausibility test

This tests several machine parameters and parts of the circuitry for their plausibility:

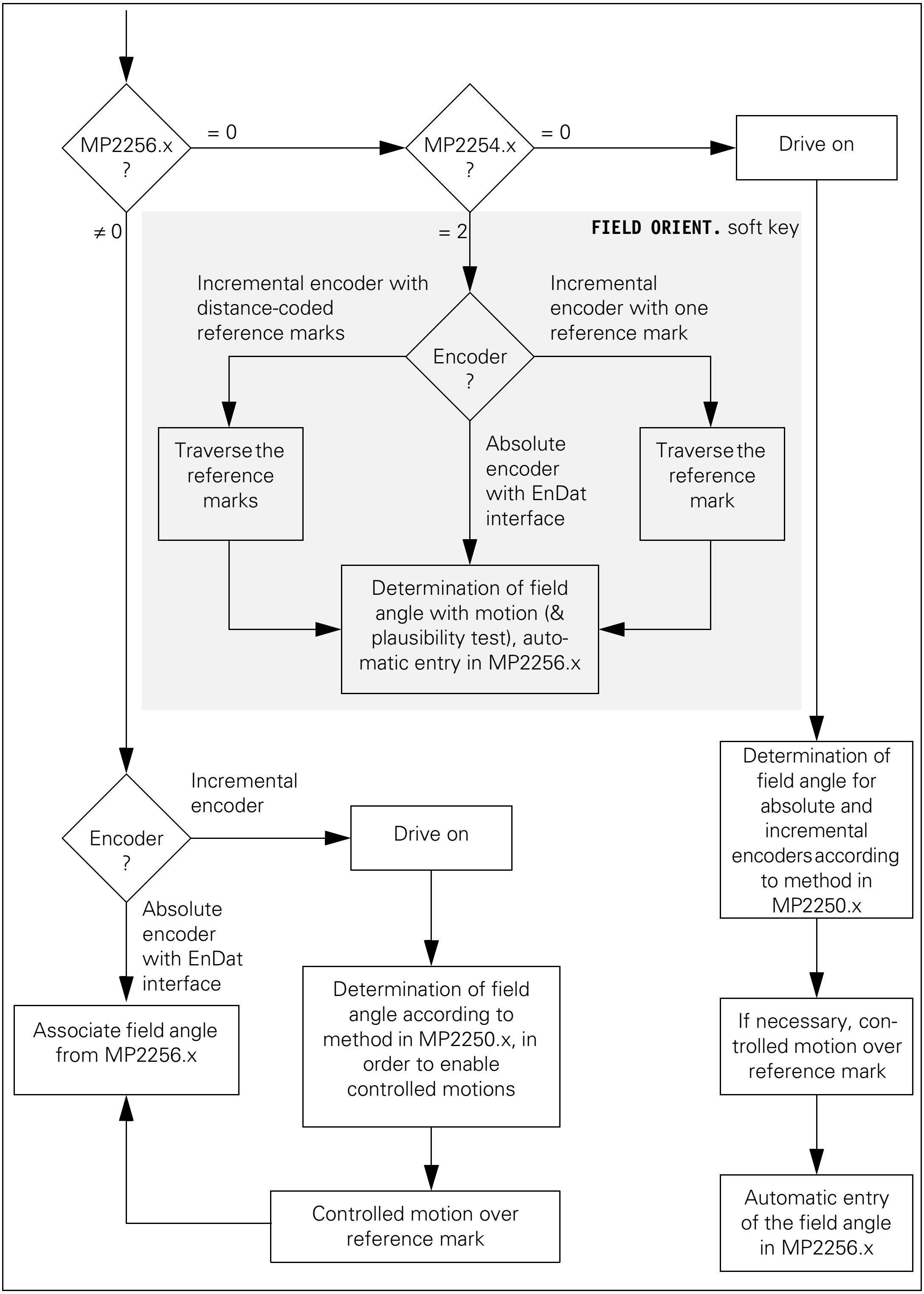
- Encoder line count
- Number of pole pairs
- Rotational direction of the electrical field
- Traverse distance per electrical revolution

> **Note**
>
> This method for determining the field angle is recommended for commissioning, new designs, and other similar situations.

The following messages can appear during the plausibility test:

- **8630 Field orient. successful**
  Indicates that the field angle was successfully determined and stored in MP2256.x.
- **8B10 Wrong traverse direction**
  Indicates that the rotational direction of the electrical field does not match the counting direction of the encoder.
  Error fix: Change the entry in MP2204.x.
- **8B20 Error field orientation**
  Indicates that no usable measuring results could be determined.
  A common cause is incorrect values in MP331.x, MP332.x and MP1054.x.
  A further cause could be that the motor is moving against a resistance (e.g. brake is still active, bellows, limit stop) or that the mechanics are too stiff.

Overview of the field orientation



7.10.2 Determination of the Field Angle without Motor Motion (MP2254.x = 0)

A distinction must be made if you intend to determine the field angle without motor motion:

- Commissioning: No field angle has been determined yet (MP2256.x = 0)
- A field angle has been already determined (MP2256.x≠0)

The field angle is determined automatically after switching on the drive. This process lasts approximately 4 to 6 seconds (the PLC program must not rescind the drive release during this time). The **Finding field angle** message appears.

If the power module is not active before the determination of the field angle begins, the error message **8B40 No drive release <axis>** appears. If the power module switches off during the determination, **8B50 Axis module <axis> not ready** appears.

Field angle not yet determined (MP2256.x = 0)

If the field angle on this machine was not yet determined after the control was started (MP2256.x = 0), the determination starts automatically. The method for determining the field angle is stored in MP2550.x. The determined field angle is stored in MP2556.x.

Field angle already determined (MP2256.x ≠ 0)

If the field angle on this machine was already determined after the control was started (MP2556.x ≠ 0), a distinction must be made:

- If an absolute encoder with EnDat interface is being used:
  The absolute position of the encoder is read immediately after the control has been started. The field angle from MP2256.x is assigned to this position. Therefore, the first motor motion already occurs with the determined field angle.
- If an incremental encoder is being used:
  Immediately after the control has been started and the control voltage has been switched on, then depending on MP2250.x a field angle is determined with which the motor can be traversed over the reference mark. After traversing the reference mark, the field angle from MP2256.x is assigned. The subsequent motor motions utilize the field angle from MP2256.x.

Determining the field angle

There are two methods for determining the field angle without motor motion:

- Method 2: Current pulses are output with the brakes applied, and the absolute rotor position is determined from the reaction.
- Method 3: Method 3 functions in the same manner as Method 2, but with the difference that the motor brakes are not applied. Therefore, this method is not suitable for hanging axes. However, this method can lead to more exact results than Method 2, so it should be used for synchronous spindles. Minimal spindle movements can occur during field angle determination.

▶ In MP2250.x, select the method to be used for determining the absolute rotor position.

Note

Standstill monitoring is active while determining the field angle. If it responds for motors without motor brakes, increase the threshold in MP1110.x. Afterwards, reset MP1110.x to the original value.

MP2250.x **Determining the field angle without motor motion**
Input: 0: Same as input value 2
1: Reserved
2: Method 2 (brakes applied)
3: Method 3 (same as Method 2, but motor brake is not applied)

MP2252.x **Reserved**
Input: Enter 0

7.10.3 Determination of the Field Angle with Motor Motion (MP2254.x = 2)

Since the motor moves in a certain direction while finding the field angle, it should be near the midpoint of the traverse path before the field angle is determined.
Axes with linear/torque motors can be slid "by hand" if the brakes are not applied.

While the field angle is being found, the speed controller and position controller are opened and the drive controller is active. This means that the motor is moved and the brake must be open until the field angle is determined.

Danger

Hanging axes require a 100% compensation for weight.
Please contact HEIDENHAIN if this is not the case.

Warning

Limit switches are ignored!
If axes move into an illegal area, press the emergency stop button!

Note

When using incremental encoders with distance-coded reference marks, MP334.x (nominal increment between two fixed reference marks) must be set correctly.

The PLC initial servicing program, whose name and path is entered in the OEM.SYS file after the **PLCPWM =** entry, must ensure that the inverters are ready after "Switch on external dc voltage," but that the motor brakes are only open while determining the field angle. Alternately, the motor brakes can be opened manually for the duration of the field angle determination.

Module 9065 Status of the commissioning function

Module 9065 provides the information as to which axis is currently in the field angle acquisition. This makes it possible to open the brake for this axis.

Call:

PS	B/W/D/K	<Commissioning function> 0: Field angle determination
CM	9065	
PL	B/W/D	<Bit-coded control loop for which the field angle determination is active>

Error detection:

Marker	Value	Meaning
M4203	0	Control loop determined
	1	Error code in W1022
W1022	1	Invalid commissioning function

Before determining the field angle (**FIELD ORIENT.** soft key not yet pressed) the inverter must be in the following mode of operation:

- Green "READY" LED on
- Red "SH1" LED off
- Red "SH2" LED on (drive controller not ready, brakes closed)

As soon as the drive enable comes from the PLC, the **Finding field angle** message appears, otherwise **8B40 No drive release** appears.

The motor moves and the field angle is determined. Limit switches are not taken into account.

- Switch on the control.
- Do **not** acknowledge the **Power Interrupted** message. In the **Programming and Editing** mode of operation, use the MOD key to enter the code number **688379.** The oscilloscope is started.
- Press the **I CONTROL** soft key.
- In the **Manual** mode of operation, acknowledge the **Power Interrupted** message.
- Use the **CHOOSE AXIS** soft key in the oscilloscope to select the corresponding axis.
- Press the **FIELD ORIENT.** soft key.

  The PLC must

  - switch the drive on/off
  - release and lock the brakes

The motor moves back and forth. The field angle is determined for the reference mark or datum, and is stored automatically. The **Finding field angle** message appears. Then another message appears (see page 7 – 16).

- Press the END soft key.

The control carries out a reset. If the message **8630 Field orient. successful** appears, then the field angle was associated and is available.

7.10.4 Saving the Determined Field Angle

NC software: 340 420-xx, to 340 422-02 and to 340 480-03
The determined field angle is automatically stored on the hard disk.
If the Field Orientation function is not run, the following error message appears:

- Encoder with EnDat interface: **8830 EnDat: no field angle <axis>**
- Encoder without Z1 track: **8820 Field angle unknown <axis>**

NC software: as of 340 422-03, as of 340 480-03
The determined field angle is automatically entered in MP2556.x.

For purposes of reliability and redundancy, either the serial number of the encoder (only for EnDat interface) or a unique control ID is entered as identification in MP2257.x.

If the current identification does not match the entry in MP2257.x, an error message appears:

- When using an encoder with EnDat interface, the error message **8830 EnDat: no field angle <axis>** appears. In any case the field angle must be determined anew, since the encoder does not match the field angle from MP2256.x
- When using an incremental encoder, the error message **MP2257.<index> incorrect (ID=$<identification>)** appears. The field angle from MP2256.x and the new identification **(ID=$<identification>)** for MP2257.x can only be assumed after determining that the same drive is meant (e.g. after changing controls).

Danger

In all other cases the field angle must be determined anew, since otherwise uncontrolled drive motions could occur!

Note

You can force a new field angle determination be entering MP2256.x = 0 (for example, after exchanging a motor or encoder).

MP2256.x	**Determined field angle**
Input:	0: Field angle does not need to be determined, or has not been determined
MP2257.x	**Control or encoder identification for the field angle from MP2256.x**
Input:	0: Field angle does not need to be determined, or has not been determined

7.11 Special Characteristics during Adjustment of Linear and Torque Motors

7.11.1 General Information

Linear and torque motors should be used only in connection with the CC 424. These motors should be connected to controllers at double speed (PWM output X55, X56, X57 to X60).

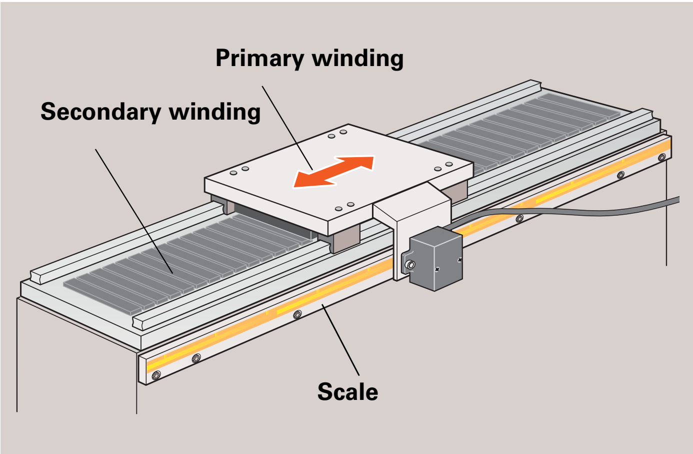
The internal oscilloscope of the iTNC can operate at a maximum resolution of only as fine as 600 µs, but the feedback control can operate at resolutions as fine as 100 µs.
Frequencies higher than 1/(600 µs · 2) = 833 Hz result in undersampling. This can result in misinterpretation of the oscilloscope image. High frequencies are mirrored downward. For example, a 1000-Hz oscillation appears as a 833 Hz - 167 Hz = 666-Hz oscillation.

Note

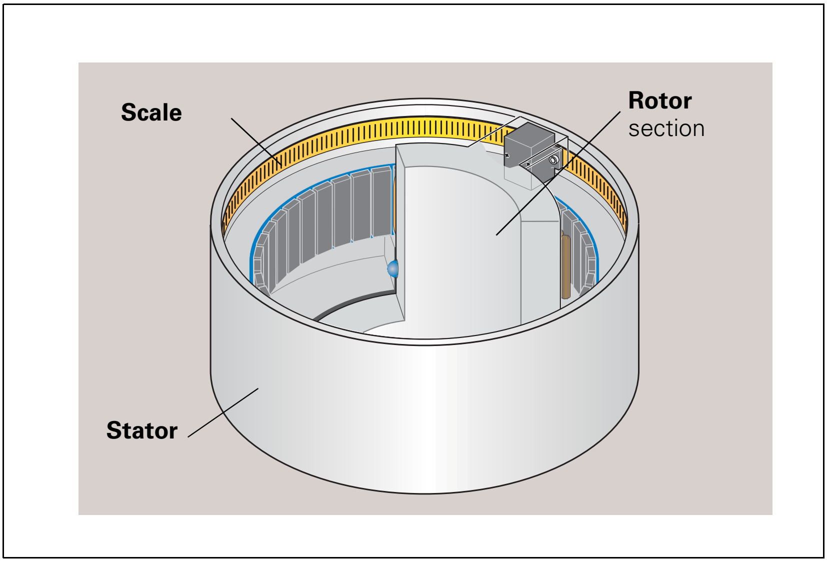
In order to avoid misinterpreting the oscilloscope image, **TNCopt** should be used when searching for oscillation frequencies or optimizing the controller.

For the CC 424, TNCopt and the internal oscilloscope display effective values, as opposed to the peak values of the CC 422.

Linear motor setup



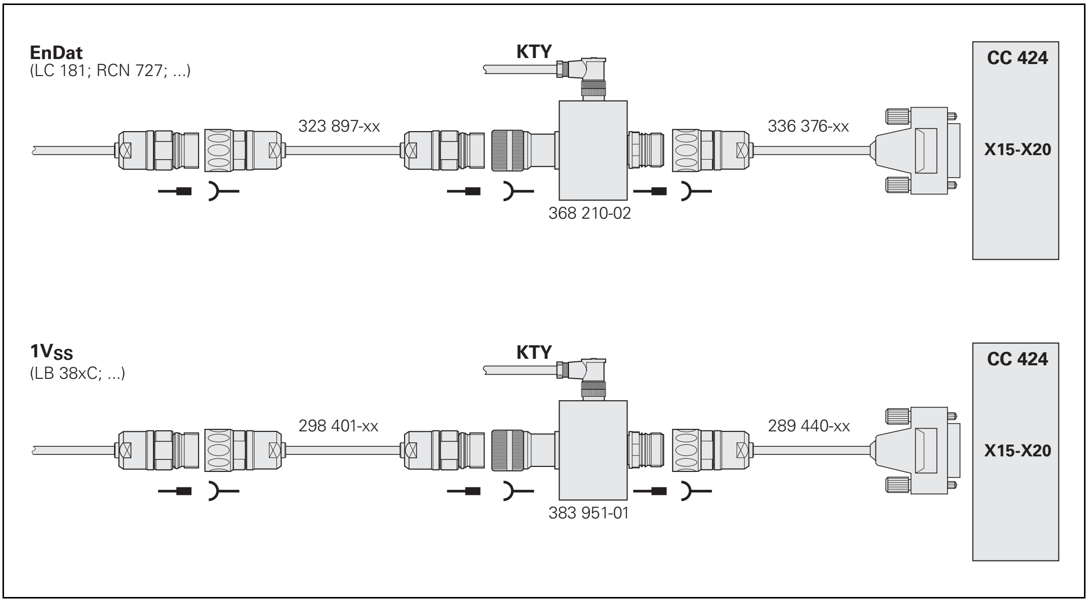
Torque motor setup



Position and speed encoders

For linear and torque motors, linear encoders are used as speed encoders. Therefore, they must be connected to the speed encoder inputs (X15 to X20, X80 to X83) .

In order to adapt the pin layouts (See “Encoder Connections” on page 3 – 28) for absolute encoders with EnDat interface (e.g. LC, RCN), you must use the line drop compensator with the ID Nr. 336 697-03, and for incremental encoders with 1 V_{PP} signals (e.g. LB, ROD) you must use the line drop compensator with the ID Nr. 383 951-01.
The temperature sensor (KTY 84) can also be connected to both line drop compensators.



Temperature sensor

Linear motors usually have a KTY and several PTC thermistors or thermoswitches for temperature measurement.

> **Warning**
>
> The PTC thermistors or thermoswitches must be **metallically isolated** and evaluated by the PLC.
>
> The KTY requires **double insulation** to the motor windings, which must be provided by the motor manufacturer. Otherwise, do **not** connect the KTY to the control!

The KTY is monitored by the control (NC). The temperature signal is conducted to the control together with the encoder signals (X15 to X20, X80 to X83). If the KTY is not to be evaluated, this function must be deactivated over MP2220.x bit 4 = 1. See “Monitoring Functions” on page 7 – 9.

For linear and torque motors, the conductor for the temperature signal of the KTY is frequently in the motor power cable, which can cause interference. Since the conductor for the temperature signal is then led into the conductor of the speed encoder , the interference causes noise in the encoder signals. HEIDENHAIN therefore recommends conducting the temperature signals over the line drop compensator, so that the interference signals are filtered.

> **Note**
>
> HEIDENHAIN recommends the additional temperature monitoring of the PTC thermistors or thermoswitches via the PLC, since these are distributed over the entire length (linear motors) or circumference (torque motors) (as opposed to the KTY, for which there are only spot measurements).

For example, PTC thermistors can be connected to a PLC input via the securely grounded 3RN1013-1BW10 thermistor motor-protection device from SIEMENS.

7.11.2 Safety Precautions for Linear and Torque Motors

Note

Comply strictly with the warnings and safety precautions printed in this chapter. They help to prevent damage to material through improper handling!

Danger

Linear and torque motors are equipped with strong magnets and exercise strong magnetic forces of attraction!

This can endanger health directly (e.g. for people with pacemakers), or indirectly (e.g. through fast motor movements and high thrust force).

Danger

- **Please comply with all safety regulations of the motor manufacturer!**
- **Never put your hands in the traverse range of a machine that is switched on.**
- Always switch off the machine before working within the traverse range (machine must be free of potential).
- Ensure free traverse for the axis.
- Before switch-on, check the commutation.
- Monitor the end positions.
- Keep the motor area free of chips.
- Watch out for unusual noises.
- Ensure proper function of the motor coolant system.
- Check in regular intervals the primary and secondary surfaces on the side toward the air gap.
- Check for mechanical stability. The integrated buffer must be able to absorb the energy at V_{max} in case of a fault.

Warning

Please comply with the following instructions during all servicing work:

- Mounting, servicing for initial operation, and maintenance are to be performed only by trained personnel.
- Wear work gloves during installation and maintenance work.
- Persons with pacemakers must not service the machine.
- Keep clocks and magnetized data media (e.g. credit cards, floppy disks, etc) at a distance.
- Do not allow heavy metallic objects to contact the secondary part of the motor.
- Never allow magnetic surfaces to contact metal.
- Never place the primary winding directly onto the secondary winding.
- Keep a good grip on steel tools and bring them to the secondary winding only slowly and from the side.

7.12 Commissioning Linear and Torque Motors

In this example a linear motor (Siemens 1FN3900-4WB0) and a torque motor (ETEL TMA0360-070-3UC) are adjusted.
If the motors are not yet found in the motor table, enter them in the table using the data sheet values and the conversion rules (See "Determining Entries for Motor Tables" on page 7 – 42), or contact HEIDENHAIN.

7.12.1 Machine Parameters for Linear Motors

The following machine parameters can be defined for the 1FN3900-4WB0 linear motor (rotational speed and position measurement through LC 181):

- MP331.x = 0.016 [mm] (with use of an LC 181)
- MP332.x = 1
- MP1350.x = 5 (linear encoder with EnDat interface)
- MP1054.x = 46[mm/rev]
- MP2100.x = HEIDENHAIN-UM114
- MP2200.x = 1FN3900-4WB0
- MP2202.x = * (distance traveled per electrical period as in the motor table)
- MP2204.x = * (counting direction as in the motor table; if the rotating field does not match the counting direction, enter "–")
- MP2206.x = * (encoder as in the motor table)
- MP2220.x bit 4 = 1 (no monitoring for excessive temperature, since the temperature sensor only has a single insulation layer)

If speed and position are measured by an LB 3xx C, the following machine parameters change:

- MP331.x = 0.004 [mm] (with use of an LB 3xx C)
- MP332.x = 1
- MP334.x = 2000
- MP1350.x = 4 (linear encoder with distance-coded reference marks)
- MP2204.x = * (counting direction as in the motor table; if the rotating field does not match the counting direction, enter "–")
- MP2206.x = 8 (incremental linear encoder with distance-coded reference marks (not aligned))

7.12.2 Machine Parameters for Torque Motors

The following machine parameters can be defined for the ETEL TMA0360-070-3UC torque motor (rotational speed and position measurement through RCN 723):

- MP331.x = 360 [°]
- MP331.x = 32768 (with use of an RCN 723)
- MP1350.x = 5 (linear encoder with EnDat interface)
- MP1054.x = 360
- MP2100.x = HEIDENHAIN-UM114
- MP2200.x = ETEL TMA0360-070-3UC
- MP2202.x = * (line count as in the motor table)
- MP2204.x = * (counting direction as in the motor table; if the rotating field does not match the counting direction, enter "–")
- MP2206.x = * (encoder as in the motor table)

7.12.3 Adjustment of the Current Controller

- Enter as many machine parameters as possible
- Assign empirical values to machine parameters that must still be determined (See "Preparation" on page 6 – 248).

Danger

During current controller adjustment of linear and torque motors, the rotor position of the motor is not yet known.
For this reason, if the motor brakes are not active, the motor might move slightly when the current pulses switch on. In other words, it might oscillate about a preferred position. It is not possible to position "manually" to the preferred position. Do not do this, however, during a measurement.

Use the integrated oscilloscope or **TNCopt** to adjust the current controller.

During adjustment of the current controller the speed controller and position controller are open. During output of the current pulses the drive controller becomes active.

The PLC initial servicing program, whose name and path is entered in the OEM.SYS file after the **PLCPWM =** entry, must ensure that the inverters are ready after "Switch on external dc voltage," but that the motor brakes are not opened.

Before and after the output of the current pulses (**START STEP** soft key is not pressed) the inverter must be in the following operating mode:

- Green "READY" LED on
- Red "SH1" LED off
- Red "SH2" LED on (drive controller not ready)

During output of the current pulses:

- Green "READY" LED on
- Red "SH1" LED off
- Red "SH2" LED off (drive controller ready)

During current adjustment, proceed as follows:

- Switch on the control.
- Do not acknowledge the **Power Interrupted** message. In the **Programming and Editing** mode of operation, use the MOD key to enter the code number **688379**. The oscilloscope is started.
- Press the **I CONTROL** soft key.
- In the **Manual** mode of operation, acknowledge the **Power Interrupted** message and switch the control voltage on.
- Use the **CHOOSE AXIS** soft key in the oscilloscope to select the axis to be adjusted.
- With the **P/I FACTOR**soft key, select the I factor and set MP2430.x = 0.
- With the **P/I FACTOR** soft key, select the P factor.
- As a starting value for the P factor first enter the value 0, select the step increment **SLOW**, and press the ↑ soft key about 5 to 10 times.
- Press the **START STEP** soft key.
  This sends multiple step functions to the current controller and measures the step responses. The height and length of the steps are automatically calculated by the control.

Creation of a voltage causes a brief humming noise.

Danger

If the brakes are not active, the motor can move somewhat (in the direction of a preferred position)!
The error message **Standstill monitoring <axis>** might be displayed. It can be deleted.

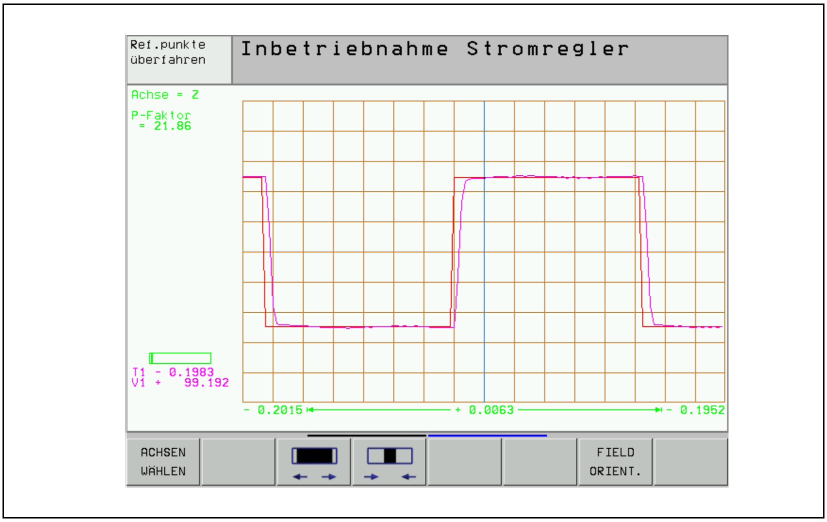
- With the ↑ soft key, increase/decrease the P factor (MP2420.x) step by step just enough so that no undershoot is visible
- Save this value with the **STORE MP2420.x** soft key.
- With the **P/I FACTOR** soft key, select the I factor.
- As a starting value for the I factor first enter the value 0, select the step increment **SLOW**, and press the ↑ soft key about 5 to 10 times.
- With the ↑ soft key, increase/decrease the I factor (MP2430.x) step by step just enough so that no undershoot is visible
- Save this value with the **STORE MP2430.x** soft key.
- Press the END key to exit the **Commission Current Controller** mode.

The control carries out a reset.

Note

For **linear and torque motors,** adjust the P and I component of the current controller so that no overshoots are visible in the step response. This reduces motor noise.

Properly adjusted step response:



7.12.4 Adjustment of the Speed Controller

The speed controller should be adjusted to largely suppress oscillation frequencies but to permit short rise times.

The following table shows approximate input values for commissioning the speed controller so that axes can be moved:

Machine parameters	Value
MP1510.x	1 to 5; k_V factor for velocity feedforward control
MP2500.x	1 to 50 for linear motors (starting value 1); 50 to 5000 for torque motors (starting value 50)
MP2510.x	10 to 2000 for linear motors (starting value 10); 1000 to 800 000 for torque motors (starting value 1000)
Increase positioning window and position monitoring	See "Commissioning" on page 6 – 234
MP2562.x to MP2566.x	0 (deactivate all filters)
MP2602.x, MP2604.x	0 (without IPC)

The current controller must have been adjusted and the field angle ascertained (See "Adjustment of the Current Controller" on page 7 – 31 and See "Field Orientation" on page 7 – 14).

Preparation on the control

- Position the axis or spindle to be optimized at a location where it can be commissioned safely.
- Ensure that the loaded PLC program fulfills the following conditions:
  - Enable the drive controller
  - NC stop inactive
  - Axis direction buttons active

As opposed to the CC 422, the internal oscilloscope of the control no longer needs to be started when adjusting the speed controller of the CC 424 with TNCopt.

Setting the filters in the speed controller

- To determine the oscillation frequencies of the speed controller, activate the **Optimization/speed controller step response** function in TNCopt.

The oscillation frequencies of the speed controller for linear and torque motors must be determined at slow feed rate in positive and negative traverse direction, and in the midpoint and end of the traverse range.
Later you enter the ascertained frequencies, bandwidths and damping in the corresponding machine parameters (MP2542.x to MP2566.x). Normally no more than three filters are required.

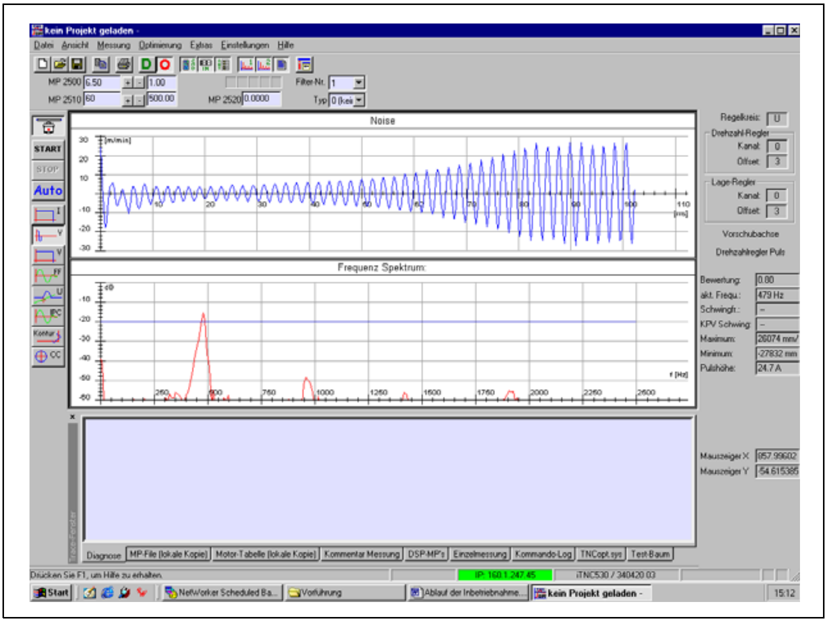
Experience recommends:

- At very small frequencies (< 200 Hz) use no filters
- Use very little damping (3 dB to 6 dB) at low frequencies (200 Hz to 400 Hz)
- The bandwidth should be approximately at center frequency
- Damping values are normally between 3 dB and 18 dB. Damping above 18 dB usually brings no further improvement.
- The use of a PT2 filter on linear motors does not bring positive results. For torque motors it is sometimes necessary to activate a PT2 filter (not below approx. 400 Hz).

Note

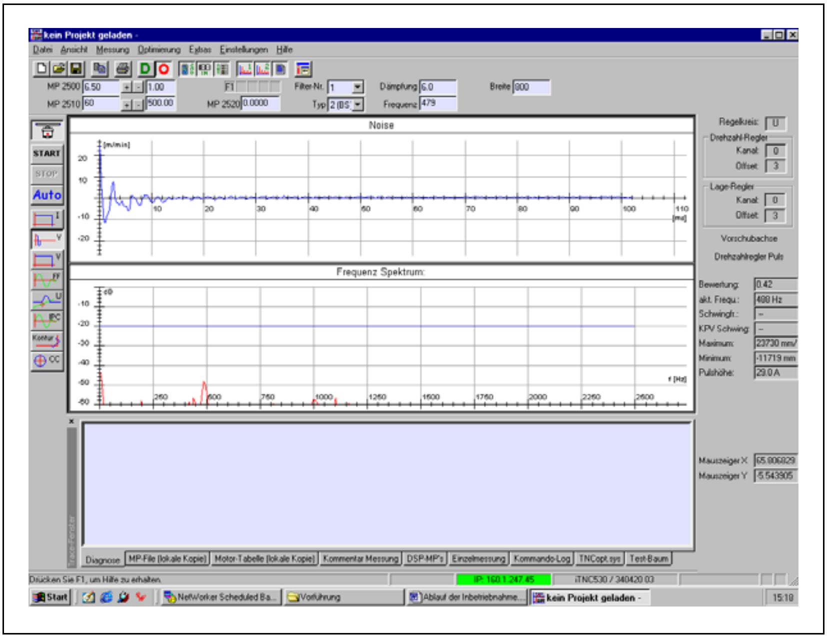
Only use the filters in the speed controller if they are necessary, i.e. if the P factor can be increased noticeably.

- For P and I factors, set low values at first:
(for linear motor: P factor = 1, I factor = 10;
for torque motor: P factor = 50, I factor = 100).
- Increase the P factor up to the oscillation limit in 10% steps
(see the User's Manual for TNCopt).



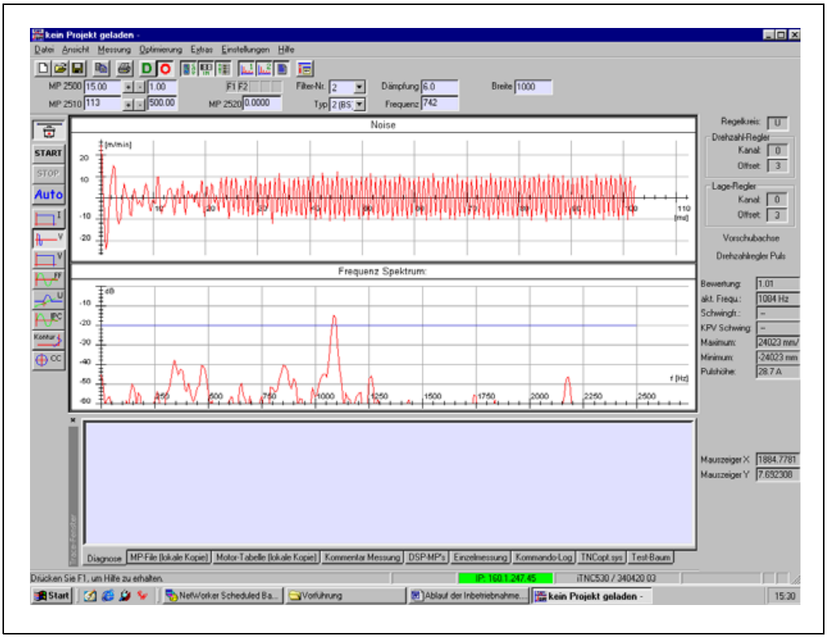
- Find the characteristic values of the first filter (F1):
Enter the oscillation frequency (e.g. at 479 Hz),
Enter the bandwidth (e.g. 479 Hz, center frequency),
Enter the damping (3 dB)
- Examine the step response
- Check whether a constant P factor decreases the excessive value
- Increase the damping in 3-dB steps (damping greater than approx. 18 dB
normally has no benefit)

▶ Examine the step response. The oscillations should be greatly decreased



▶ Increase the P factor further

This may cause new oscillations.
When selecting filters, watch whether your selection causes or aggravates negative characteristics. If it does, do not activate any further filters.



After finding the oscillation frequencies, several filters can be activated.

- On the control, enter the determined filter type (MP2562.x to MP2566.x), the determined center frequency (MP2552.x to MP2556.x), the determined bandwidth (MP2572.x to MP2576.x) and the determined damping (MP2542.x to MP2546.x)

Adjusting synchronous and asynchronous motors

Synchronous and asynchronous motors are adjusted as described in the TNCopt User's Manual.

Use a filter if a sufficiently short enough rise time is not achieved (approx. 3 ms) (See "Setting the filters in the speed controller" on page 7 – 35). Using a filter also results in an increased P factor. The I factor must then be redetermined.

In most cases automatic adjustment of synchronous and asynchronous motors determine rise times that are too short (< 2 ms). Rise times that are too short result in irregular control responses. In this case both the P and I factors must be reduced (until a rise time of approx. 2 ms is achieved).

Adjusting linear and torque motors

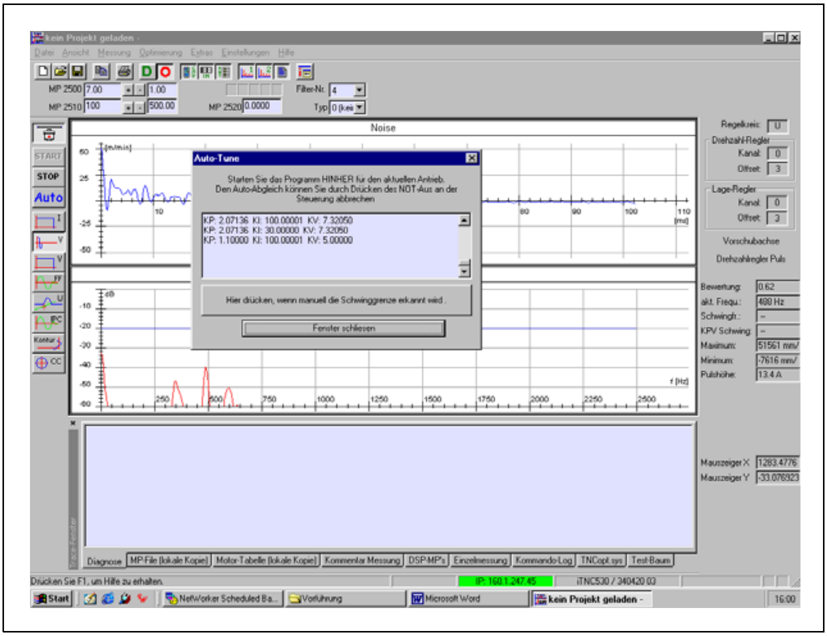
- First determine the oscillation frequencies and adjust the filters, See "Setting the filters in the speed controller" on page 7 – 35
- To adjust linear and torque motors, activate the **Optimization/Linear motor adjustment** function in TNCopt.

This makes it possible to automatically find the controller parameters in the sequence P factor, k_V factor, I factor (also see the TNCopt User's Manual). An NC program must be started in which the motor is moved back and forth.

Because inhomogeneity of magnets, changing the air gap, or other factors can cause linear motors to oscillate more strongly at certain positions, HEIDENHAIN recommends adjusting the motor over a large range of traverse (approx. 300 mm to 500 mm).

During adjustment, TNCopt now automatically increases the newly adjusted controller factor after each reversal point until it detects an oscillation limit. The respective current value is displayed in TNCopt. Usually you can already hear the oscillation limit being reached. In this case the oscillation limit is set per command button (see the TNCopt User's Manual). The factors are reduced after detection of the oscillation limit. Then they are considered to be optimized values.

Particularly the optimization of the I factor often results in very low frequency oscillations that the controller does not recognize as oscillations. Here the oscillation limit must be set by command button.



- Move the axis back and forth.

The P factor (and then k_V factor and I factor) are automatically increased by 10 % of the current value.

- As soon as you hear an oscillation in the axis (also visible on the iTNC's oscilloscope with **`I noml`**), set the oscillation limit via command button (see the TNCopt User's Manual).

The determined P factor (and then k_V factor and I factor) are reduced and assumed.
TNCopt automatically switches to finding the next factor

- Also repeat the finding of the k_V factor and I factor

The P , I and k_V factors were found.

- Enter the determined values at the control in MP2500.x, MP2510.x and MP1510.x

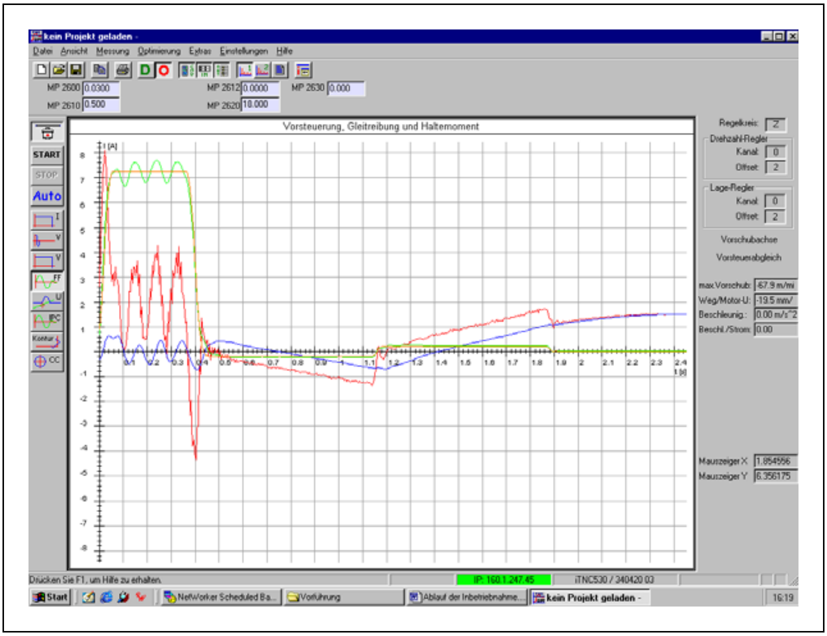
Finding the feedforward values

Automatic adjustment of feedforward values in TNCopt often fails for linear motors. The reason is the often extreme ripple of the nominal current due to the pronounced torque ripple. But even if the automatic adjust does not work, TNCopt can still be used for manual adjustment.

The proposed curves are sometimes not the optimum for linear motors. It can therefore be better for manual adjustment if you increase the traverse paths and the feed rate (by approximately doubling it, for example) and adjust the acceleration in MP1060 to about 1 m/s^2 to 2 m/s^2.

If the integral current should approach the nominal current only very slowly, reduce the k_V factor and increase the I factor. However, these changes should be undone after determining the feedforward values.

The following image shows an adjustment of a very critical linear motor that has a decidedly inhomogeneous magnetic field. This can be seen from the nominal current, which fluctuates very strongly depending on the position:



7.13 Determining Entries for Motor Tables

Note

If you use a linear or torque motor that is not listed in the current HEIDENHAIN motor table, please contact HEIDENHAIN. As an alternative, you can also determine the input values yourself.

7.13.1 Determining Data for Linear Motors

The motor data for linear motors are entered in the motor table after some conversions using the values from the motor data sheet of the respective manufacturer (here using the example of a Siemens motor).

Values in the HEIDENHAIN motor table	Values from the motor data sheet
TYPE: LSM	Permanently excited **L**inear **S**ynchronous **M**otor
NAME: 1FN3900-4WB0	1FN3900-4WB0
MODE: 0	
Rated current I-N in [A_{eff}] winding I-N: 49.4	Data sheet value I_N I_N = 49.4 A
Rated voltage U-N in [V_{eff}] interlinked U-N: 394	Calculation from data sheet values F_N, I_N, $R_{P.120}$, L_P $U\text{-}N = \sqrt{3} \cdot \sqrt{(U_e + U_r)^2 + U_x^2}$ U_e = N-N / (1000mm/m) · F_N / (I_N · 3) = (2.66 m/s) · 8100 N / (49.4 A · 3) = 145.4 $V_{eff\ L\text{-}N}$ U_r = $R_{P.120}$ · I_N = 0.8 Ω · 49.4 A = 39.5 $V_{eff\ L\text{-}N}$ U_x = 2 · π · F-N · L_P · I_N = 2 · π · 57 Hz · 0.0075 H · 49.4 A = 138.77 $V_{eff\ L\text{-}N}$ U-N = 394 $V_{eff\ (L\text{-}L)}$
Rated speed N-N in [mm/s] N-N: 2666	Calculation from data sheet value $v_{MAX,FN}$ N-N = (1000 mm/m) · $V_{MAX,FN}$ / (60 s/min) = (1000 mm/m) · (160 m/min) / (60 s/min) = 2666 mm/s Note: Other meaning than for rotating motors!
Rated frequency F-N in [Hz] F-N: 57	Calculation from V-N, distance per electrical period (see entry in STR column) F-N = N-N · (1000 µm/mm) / (distance per elec. period [µm]) F-N = (2666 mm/s) · (1000 µm/mm) / (46 000 µm) = 57 Hz

Values in the HEIDENHAIN motor table	Values from the motor data sheet
No-load voltage at rated velocity U0 in [V_{eff}] interlinked U0: 252	Calculation from V-N and data sheet value $k_{F,3}$ U0 = N-N / (1000 mm/m) · ($k_{F,3}$ / 3) · √3 = 2.66 m/s · (164 N/A / 3) · √3 = 252 V_{eff} L,L
No-load current I0 in [A_{eff}] winding I0: 0	
Primary winding resistance at 20 °C R1 in [mΩ] at 20° C R1: 600	Calculation from data sheet value $R_{P,20}$ R1 = $R_{P,20}$ · 1000 = 0.6 Ω ·1000 = 600 mΩ
Rotor resistance at 20 °C R2 in [mΩ] at 20° C R2: 0	
Primary winding leakage reactance at F-N Xstr1 in [mΩ] Xstr1: 0	If nothing given, then zero.
Runner leakage reactance at F-N Xstr2 in [mΩ] Xstr2: 0	
Magnetizing reactance XH for F-N at rated conditions XH in [mΩ] XH: 2685	Calculation from F-N and data sheet value L_P XH = 2 · π · F-N · L_P = 2 · π · 57 Hz · 7.5 mH = 2685 mΩ
Desaturation velocity N-XH in [rpm] N-XH: 0	
Rotational speed of beginning field weakening range N-FS [rpm] N-FS: 0	
Max. velocity (mechanical) N-MAX in [mm/s] N-MAX: 2666	Calculation from data sheet value $v_{MAX,FN}$ N-MAX = 160 m/min · (1000 mm/m) / (60 s/min) = 2666 mm/s Note: Other meaning than for rotating motors!
Saturation factor %-XH in % %XH: 100	
Stalling torque reduction factor %-K in % %-K: 100	
No. of pole pairs (half pole no. of motor) PZ PZ: 1	
Temperature coefficient of the primary winding TK in 1/K TK: 0.004	

Values in the HEIDENHAIN motor table	Values from the motor data sheet
Distance per electrical period STR STR: 46 000	Calculation from data sheet value τ_M Path $= \tau_M \cdot 2 \cdot (1000\ \mu m/mm)$ $= 23\ mm \cdot 2 \cdot (1000\ \mu m/mm)$ $= 46\ 000\ \mu m$ Note: Other meaning than for rotating motors!
Type of encoder SYS: 3	Incremental encoder (e.g. LB): 8 Absolute encoder with EnDat interface (e.g. LC): 3
Counting direction DIRECT. DIRECT.: +	
Max. temperature of motor at temperature feeler T-MAX in [°C] T-MAX: 120	Data sheet value $T_{P, MAX}$ $T_{P, MAX} = 120\ °C$
Maximum motor current I-MAX in [A_{eff}] winding I-MAX: 138.9	Data sheet value I_{MAX} $I_{MAX} = 138.9\ A_{eff}$
Rated power P-N in [W] P-N: 21600	Calculation from data sheet values $v_{MAX,FN}$, F_N P-N = $v_{MAX,FN} \cdot (1\ min/60\ s) \cdot F_N$ P-N = 160 m/min · (1 min/60 s) · 8100 N P-N = 21600 W
Mass of primary winding J in [kg] J: 56.2	Data sheet value m_P $m_P = 56.2\ kg$ Note: Other meaning than for rotating motors!
Inductivity of the series reactor L in [µH] L: 0 µH As long as (X1str+Xh) / (2 · π · (N-N / 60) · PZ) is greater than 700 µH, no series reactor is required.	
Thermal time constant for direct current T-DC in [s] T-DC: 0	
Lower thermal cutoff frequency F-DC in [Hz] F-DC: 0	
Thermal time constant for alternating current T-AC in [s] T-AC: 0	
Upper thermal cutoff frequency F-AC in [Hz] F-AC: 0	

7.13.2 Determining Data for Torque Motors

The motor data for torque motors are entered in the motor table after some conversions using the values from the motor data sheet of the respective manufacturer (here using the example of an ETEL motor).

Values in the HEIDENHAIN motor table	Values from the motor data sheet
TYPE: SM	Permanently excited synchronous motor (SM)
NAME: Etel-TMA0360-070-3UC	TMA0360-070-3UC
MODE: 0	
Rated current I-N in [A_{eff}] winding I-N: 32.6	Data sheet value I_N I_N = 49.4 A
Rated voltage U-N in [V_{eff}] interlinked U-N: 252	Calculation from data sheet values F_N, I_N, $R_{P.120}$, L_P $\text{U-N} = \sqrt{3} \cdot \sqrt{(U_e + U_r)^2 + U_x^2}$ Ue = 2 · π · (N-N / 60) · Tcw105 / Icw105 / 3 Ue = 2 · π · (180 / 60) · 485 / 32.6 / 3 Ue = 93.48 $V_{eff\ L,N}$ Ur = ($R105_{L;L}$ / 2) · Icw105 Ur = (1.92 / 2) · 32.6 Ur = 31.30 $V_{eff\ L,N}$ Ux = 2 · π · (n / 60) · (2p / 2) · ($L1_{L,L}$ / 2) · Icw105 Ux = 2 · π · (180 / 60) · (66 / 2) · (0.00738 / 2) · 32.6 Ux = 74.83 $V_{eff\ L,N}$ U-N = 252.0 $V_{eff\ L,L}$
Rated speed N-N in [rpm] N-N: 180	Data sheet value *n* N-N = 180 rpm
Rated frequency F-N in [Hz] F-N: 99	Calculation from data sheet value *n* in 2p F-N = (n / 60) · (2p / 2) F-N = (180 / 60) · (66 / 2) = 99 Hz
No-load voltage at rated speed U0 in [V_{eff}] interlinked U0: 252	Calculation from data sheet value *n* in Kt U0 = 2 · π · (n / 60) · (Kt / 3) · √3 U0 = 2 · π · (180 / 60) · (15.7 / 3) · √3 U0 = 170.9 $V_{eff\ L,L}$
No-load current I0 in [A_{eff}] winding I0: 0	
Stator resistance at 20 °C R1 in [mΩ] at 20° C R1: 670	Calculation from data sheet value $R20_{L-L}$ R1 = $R20_{L-L}$ / 2 = 1.34 Ω / 2 = 670 mΩ
Rotor resistance at 20 °C R2 in [mΩ] at 20° C R2: 0	

Values in the HEIDENHAIN motor table	**Values from the motor data sheet**
Stator leakage reactance at F-N Xstr1 in [mΩ] Xstr1: 0	If nothing given, then zero.
Runner leakage reactance at F-N Xstr2 in [mΩ] Xstr2: 0	
Magnetizing reactance XH for F-N at rated conditions XH in [mΩ] XH: 2295	Calculation from data sheet value $L1_{L-L}$, *n* and 2p $XH = 2 \cdot \pi \cdot (n / 60) \cdot (2p / 2) \cdot (L1_{L,L} / 2)$ $= 2 \cdot \pi \cdot (180 / 60) \cdot (66 / 2) \cdot (0.00738 / 2)$ $= 2295\ m\Omega$
Desaturation speed N-XH in [rpm] N-XH: 0	
Rotational speed of beginning field weakening range N-FS [rpm] N-FS: 0	
Maximum speed (mechanical) N-MAX in [rpm] N-MAX: 180	Data sheet value *n* N-MAX = 180 rpm
Saturation factor %-XH in % %XH: 100	
Stalling torque reduction factor %-K in % %-K: 100	
No. of pole pairs (half pole no. of motor) PZ PZ: 33	From data sheet value 2p PZ = 2p/2 PZ = 66/2 = 33
Temperature coefficient of the stator winding TK in 1/K TK: 0.004	
Line count of the encoder STR STR: 32768	
Type of encoder SYS: 5	Incremental encoder with Z1 track: 1 Aligned absolute encoder with EnDat interface: 2 Unaligned absolute encoder with EnDat interface: 5 Unaligned incremental encoder with distance-coded reference marks: 7
Counting direction DIRECT. DIRECT.: +	
Max. temperature of motor at temperature feeler T-MAX in [°C] T-MAX: 120	
Maximum motor current I-MAX in [A_{eff}] winding I-MAX: 53	Data sheet value Ip I-MAX = 53.0 A_{eff}

Values in the HEIDENHAIN motor table	Values from the motor data sheet
Rated power P-N in [W] P-N: 9142	Calculation from *n* and Tcw105 P-N = 2 · π · (n / 60) · Tcw105 P-N = 2 · π · (180 / 60) · 485 Nm P-N = 9142 W
Motor mass moment of inertia J in [kgm^2] J: 0.157	Data sheet value J J = 0.157 kgm^2
Inductivity of the series reactor L in [µH] L: 0 µH As long as (X1str+Xh) / (2 · π · (N-N / 60) · PZ) is greater than 700 µH, no series reactor is required.	
Thermal time constant for direct current T-DC in [s] T-DC: 0	
Lower thermal cutoff frequency F-DC in [Hz] F-DC: 0	
Thermal time constant for alternating current T-AC in [s] T-AC: 0	
Upper thermal cutoff frequency F-AC in [Hz] F-AC: 0	