



HEIDENHAIN



MANUALplus 620

The Contouring Control for
CNC and Cycle Lathes

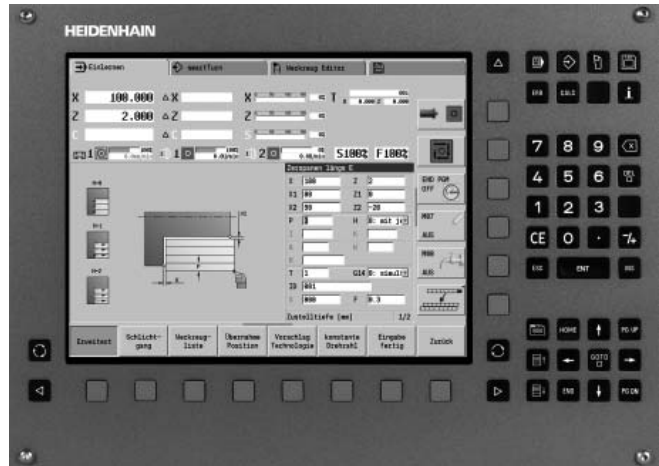
Information for the
Machine Tool Builder

MANUALplus 620

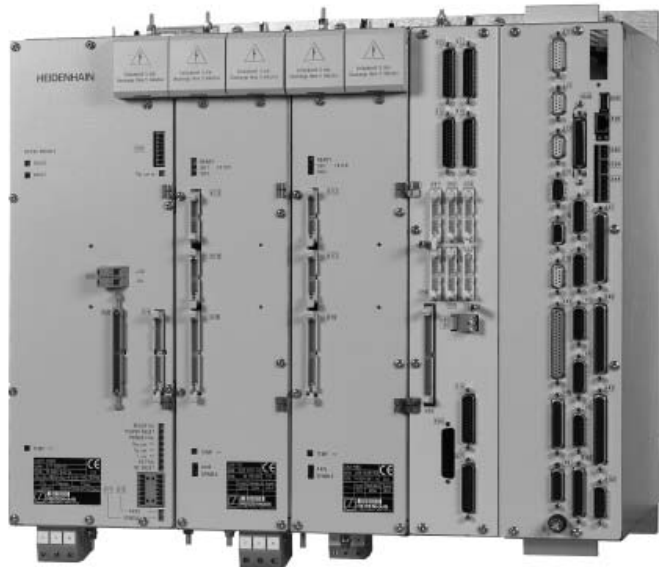
Contouring Control with Inverters

MANUALplus 620

- Contouring control for lathes with 2 axes, controlled spindle, C axis and driven tools
- HEIDENHAIN inverter systems and motors
- 12.1-inch TFT flat-panel color display
- Hard disk
- Cycle programming for turning, drilling, boring and milling operations
- smart.Turn programming for turning, boring drilling and milling operations
- DIN programming for turning, boring, drilling and milling operations
- Free ICP contour programming for turning and milling contours
- The MANUALplus supports simple tool holders (multipoint tools) and tool turrets. The tool carrier can be located in front of or behind the workpiece.
- The MANUALplus also supports vertical lathes.



BFT 131 operating panel



MC 420, CC 422
with modular inverter

System tests

Controls, motors and encoders from HEIDENHAIN are usually integrated as components in larger systems. In these cases, comprehensive tests of the complete system are required, irrespective of the specifications of the individual devices.

Parts subject to wear

In particular the following parts in controls from HEIDENHAIN are subject to wear:

- Hard disk
- Buffer battery
- Fan

Standards

Standards (ISO, EN, etc.) apply only where explicitly stated in the catalog.

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Please refer to the **page references** in the **tables** with the **specifications**.

The features and specifications described here apply for the following control and NC software version:

MANUALplus 620	ID 548328-01
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Some of these specifications require particular machine configurations. Please note also that, for some functions, a special PLC program must be created by the machine manufacturer.

This catalog supersedes all previous editions, which thereby become invalid.

Subject to change without notice

Specifications

Specifications	MANUALplus 620	Page
Control systems		
Main computer	MC 420	12
Controller unit	CC 422	14
Operating panel	<ul style="list-style-type: none"> • BFT 131 color flat-panel TFT display • NC keyboard 	15
Inverter systems		
Compact inverters	✓	*
Modular inverters	✓	*
Axes¹⁾ and spindles		
Axes	2 closed-loop axes	22
C axis	With spindle motor or separate drive (option)	22
Driven tool	Option	23
Main spindle		
Speed ²⁾	Max. 60000 min ⁻¹	22
NC program memory		
	At least 15 GB on hard disk	
Input resolution and display step		
Linear axes	X axis: 0.5 µm (diameter: 1 µm) Z axis: 1 µm	
C axis	0,001°	
Interpolation		
Straight line	In 2 axes (max. ± 100 m)	**
Circle	In 2 axes (circle radius max. ± 999 m)	**
C axis	Interpolation of X and Z linear axes with the C axis	**
Axis feedback control		
	Digital drive control for synchronous and asynchronous motors	23
With following error	✓	24
With feedforward	✓	24
With jerk limiting	✓	25

¹⁾ As ordered

²⁾ On motors with two pole pairs

* For further information, refer to the brochure *Inverters* (ID 622420-xx)

** For further information, refer to the brochure *MANUALplus 620*

Specifications	MANUALplus 620	Page														
Feed rate	Maximum feed rate: $\frac{60000 \text{ min}^{-1}}{\text{No. of pole pairs in motor}} \cdot \text{screw pitch [mm]}$ at $f_{\text{PWM}} = 5000 \text{ Hz}$	22														
Constant surface speed	✓	22														
Input	mm/min or mm/revolution	22														
Cycle times of main computer	MC 420															
Block processing	3 ms															
Position controller	3 ms	24														
Cycle times of controller unit	CC 422	24														
Speed controller	0.6 ms	24														
Current controller	<table> <thead> <tr> <th>f_{PWM}</th> <th>T_{INT}</th> </tr> </thead> <tbody> <tr> <td>3333 Hz</td> <td>150 μs</td> </tr> <tr> <td>4166 Hz</td> <td>120 μs</td> </tr> <tr> <td>5000 Hz</td> <td>100 μs</td> </tr> <tr> <td>6666 Hz</td> <td>75 μs</td> </tr> <tr> <td>8333 Hz</td> <td>60 μs</td> </tr> <tr> <td>10000 Hz</td> <td>50 μs</td> </tr> </tbody> </table>	f_{PWM}	T_{INT}	3333 Hz	150 μs	4166 Hz	120 μs	5000 Hz	100 μs	6666 Hz	75 μs	8333 Hz	60 μs	10000 Hz	50 μs	24
f_{PWM}	T_{INT}															
3333 Hz	150 μs															
4166 Hz	120 μs															
5000 Hz	100 μs															
6666 Hz	75 μs															
8333 Hz	60 μs															
10000 Hz	50 μs															
Power supply	Inverter with logic unit: 3 x 400 V~ Color flat-panel display and PLC: 24 V-															
Permissible temperature range	Operation: 0 °C to 40 °C Storage: -35 °C to +65 °C															

Machine Interfacing

Machine Interfacing	MANUALplus 620	Page
Error compensation		28
Linear axis error	✓	28
Nonlinear axis errors	✓	28
Backlash	✓	28
Hysteresis, reversal peaks	✓	28
Thermal expansion	✓	28
Stick-slip friction	✓	28
Integrated PLC		29
Program format	Statement list	29
Program input via the control	Via external USB keyboard	29
Program input via PC	✓	29
PLC memory	Hard disk	29
PLC cycle time	18 ms	29
PLC inputs, 24 V–	56 (expandable by PL)	
PLC outputs, 24 V–	31 (expandable by PL)	
Analog inputs ±10 V	3 (expandable by PL)	
Analog outputs, ±10 V	6 (expandable by PL)	
Inputs for thermistors	3 (expandable by PL)	
PLC soft keys	✓	29
PLC positioning	✓	29
PLC basic program	✓	30
Encoder inputs		26
Position	5	27
Incremental	1 V _{PP}	27
Absolute	EnDat 2.1	27
Spindle speed	6	27
Incremental	1 V _{PP}	27
Absolute	EnDat 2.1	27
Commissioning and diagnostic aids		31
Integrated oscilloscope	✓	31

Machine Interfacing, Accessories

Machine Interfacing	MANUALplus 620	Page
Trace function	✓	31
Logic diagram	✓	31
Table function	✓	31
OLM (online monitor)	✓	32
Log	✓	31
Data Interfaces		34
Ethernet (100BaseT)	✓	34
RS-232-C/V.24	Can only be controlled via PLC	34
RS-422/V.11	Can only be controlled via PLC	34
USB 1.1	2	34

Accessories	MANUALplus 620	Page
Electronic handwheels		17
Up to two HR 180	✓	17
One HR 410 or	✓	17
One HR 130	✓	17
PLC input/output systems	Modular external PL 510 I/O systems consisting of <ul style="list-style-type: none"> • Basic module with HEIDENHAIN PLC interface <ul style="list-style-type: none"> PLB 510: for 4 I/O modules PLB 511: for 6 I/O modules PLB 512: for 8 I/O modules • PLD 16-8: I/O module with 16 digital inputs and 8 digital outputs • PLA 4-4: Analog module with 4 analog inputs for ±10 V and inputs for PT 100 thermistors 	16
USB hub	✓	34
DataPilot MP 620 programming station	Control software for PCs for programming, archiving, and training	*
PLC basic program ¹⁾	✓	30
Software		
PLCdesignNT ¹⁾	PLC software developing environment	30
TNCremoNT	Data transfer software	35
TNCremoPlus	Data transfer software with "live" screen	35
TNCscopeNT ¹⁾	Software for data recording	31
DriveDiag ¹⁾	Software for diagnostics	32
TNCopt ¹⁾	Software for putting digital control loops into service	32

* For further information, refer to the brochure *MANUALplus 620*

¹⁾ For registered customers, these software products are available for downloading from the Internet.

User Functions

User functions	Standard	Option	
Configuration	<ul style="list-style-type: none"> • • • 	0-2 55+0-2	Basic version: X and Z axis, spindle Positionable spindle and driven tool C axis and driven tool Digital current and speed control
Modes of operation Manual operation	<ul style="list-style-type: none"> • • 	11	Manual slide movement through manual direction keys, intermediate switch or electronic handwheels Graphic support for entering and running cycles without saving the machining steps in alternation with manual machine operation Thread reworking (thread repair in a second workpiece setup)
Teach-in		8	Sequential linking of fixed cycles, where each cycle is run immediately after input, or is graphically simulated and subsequently saved.
Program run	<ul style="list-style-type: none"> • 	9 8	All are possible in single-block and full-sequence modes DIN PLUS programs smart.Turn programming Cycle programs
Setup functions	<ul style="list-style-type: none"> • • • • 	17 17	Workpiece presetting Definition of tool-change position Definition of protection zone Tool measurement by touching the workpiece Tool measurement with a tool touch probe Tool measurement with an optical gauge
Programming Cycle programming		8 8 8 8 8 8 8 8+55 8+55 8+55 8+55 8+55 8 8 8 8+9	Area clearance cycles for simple and complex contours, and contours defined with ICP Contour-parallel area clearance cycles Recessing cycles for simple contours, complex contours, and contours defined with ICP Repetitions with recessing cycles Recess turning cycles for simple and complex contours, and contours defined with ICP Undercut and parting cycles Threading cycles for single or multi-start longitudinal, taper or API threads Cycles for axial and radial drilling, pecking and tapping operations with the C-axis Thread milling with the C axis Axial and radial milling cycles for slots, figures, single surfaces and polygons as well as for complex contours defined with ICP for machining with the C axis Helical slot milling with the C axis Linear and circular patterns for drilling and milling operations with the C axis Context-sensitive help graphics Transfer of cutting values from technology database Use of DIN macros in cycle programs Conversion of cycle programs to smart.Turn programs
Interactive contour programming (ICP)		8/9 8/9 8/9 8/9 8/9 8/9 8/9	Contour definition with linear and circular contour elements Immediate display of entered contour elements Calculation of missing coordinates, intersections, etc. Graphic display of all solutions for selection by the user if more than one solution is possible Chamfers, rounding arcs and undercuts available as form elements Input of form elements immediately during contour creation or by superimposition later Changes to existing contours can be programmed

User functions	Standard	Option	
Programming smart.Turn programming		9 9 9 9 9 9 9 9 9+55 9+55 9 9 9 9 9 9	The basis is the unit , which is the complete description of a machining block (geometry, technology and cycle data) Dialog boxes divided into overview and detail forms Fast navigation between the forms and input groups via the “smart” keys Context-sensitive help graphics Start unit with global settings Transfer of global values from the start unit Transfer of cutting values from technology database Units for all lathe and recessing operations Units for all milling and drilling operations with the C axis Special units for activating/deactivating the C axis, subprograms and section repeats Use of the contours described with ICP for lathe and milling operations Use of the patterns described with ICP for drilling and milling patterns Program verification graphics for workpiece blank and finished part Turret assignment and other setup information in the smart.Turn program Parallel programming Parallel simulation
DIN PLUS programming	<ul style="list-style-type: none"> • • • • • • • • • • • • 	55 8/9 9	Programming in DIN 66025 (ISO 6983) format Expanded command format (IF..THEN...ELSE...) Simple geometry programming (calculation of missing data) Powerful machining cycles for area clearance, recessing, recess turning and thread machining Powerful machining cycles for drilling and milling with the C axis Subprograms Programming with variables Contour description with ICP Program verification graphics for workpiece blank and finished part Turret assignment and other setup information in the DIN PLUS program Conversion of smart.Turn units into DIN PLUS command sequences Parallel programming Parallel simulation
Test run graphics	<ul style="list-style-type: none"> • • • • • • 		Graphic simulation of the cycle process, or of the cycle, smart.Turn or DIN PLUS- program Display of the tool paths as wire-frame or cutting-path graphics, special identification of the rapid-traverse paths Machining simulation (2-D material-removal graphic) Side or face view, or 2-D view of cylindrical surface Display of programmed contours Shifting and magnifying functions
Machining time analysis	<ul style="list-style-type: none"> • • • 		Calculation of machining time and idle machine time Consideration of switching commands triggered by the CNC Representation of single times per cycle or per tool change

Overview

– Options

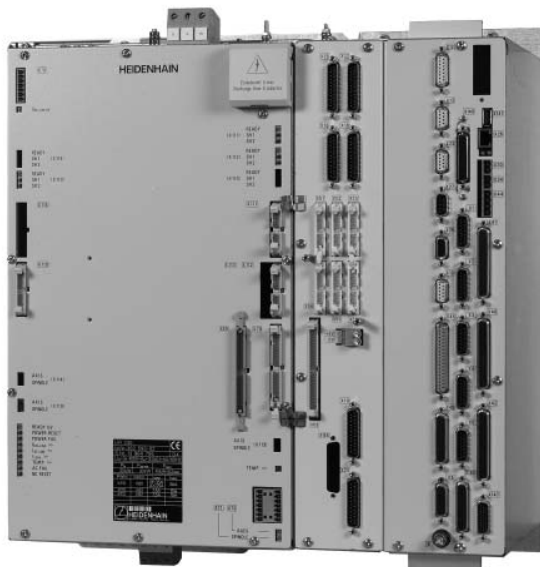
Option number	Option	ID	Comment
0 1	Additional axis	354540-01 353904-01	Additional control loops 1 and 2
8	Software option 1	632226-01	Cycle programming <ul style="list-style-type: none">• Contour description with ICP• Cycle programming• Technology database with 9 workpiece-material/tool-material combinations
9	Software option 2	632227-01	smart.Turn <ul style="list-style-type: none">• Contour description with ICP• Programming with smart.Turn• Technology database with 9 workpiece-material/tool-material combinations
10*	Software option 3	632228-01	Tools and technology <ul style="list-style-type: none">• Tool database expanded to 999 entries• Technology database expanded to 62 workpiece-material/tool-material combinations• Support of multipoint tools• Simple tool-life management
11*	Software option 4	632229-01	Threads <ul style="list-style-type: none">• Thread recutting• Handwheel superimposition during thread cutting
17*	Software option TCH PROBE functions	632230-01	Tool measurement <ul style="list-style-type: none">• Determining tool-setting dimensions with a touch probe• Determining tool-setting dimensions with an optical gauge
42*	Software option DXF-Import	632231-01	DXF import <ul style="list-style-type: none">• Loading of DXF contours
55*	Software option C-axis machining	633944-01	C-axis machining

* Availability planned for end of 2009

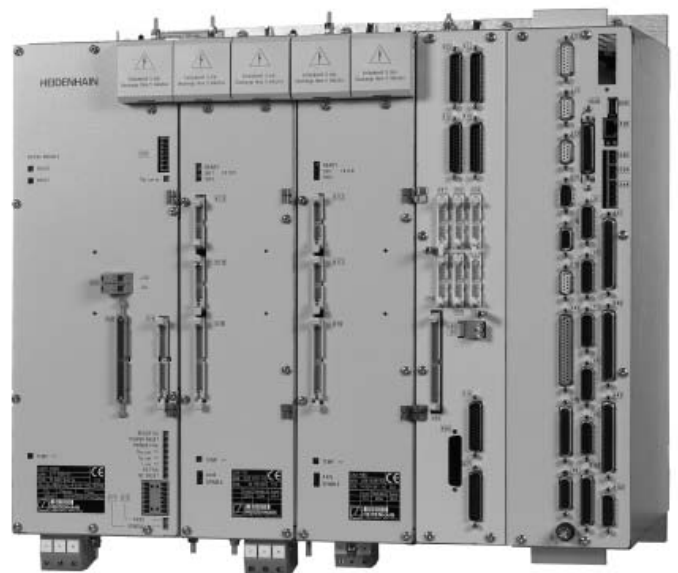
HEIDENHAIN Control Systems

The MANUALplus 620 lathe control from HEIDENHAIN includes various components, which can be selected and combined to fit the application.

		Model	Page
MANUALplus 620	Main computer	MC 420	12
	Controller unit	CC 422	14
	Operating panel	BFT 131	15
	Connecting cables		18
Accessories	PLC inputs/outputs	PL 510	16
	Electronic handwheels	HR 410, HR 180 or HR 130	17



MC 420, CC 422
with compact inverter



MC 420, CC 422
with modular inverter

Main Computer

Main Computer

The **MC 420** main computer includes:

- Processor (Celeron, 400 MHz)
- 512 MB RAM memory
- PLC
- Interface to the CC controller unit
- Interface to the control panel
- Interface to the handwheel
- Further interfaces (PLC expansion, Ethernet, USB, RS-232-C/V.24, RS-422/V.11)

To be ordered separately:

- **HDR** hard disk with the NC software
- **SIK component** (System Identification Key) for enabling the control loops and software options

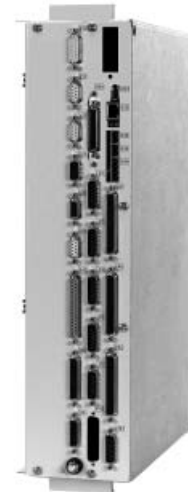
Power supply

The main computer is powered over the CC controller unit.

MC 420

The MC 420 main computer features five position encoder inputs.

Position inputs	5 x 1 V _{PP} or EnDat 2.1
Weight	4.2 kg
ID	515929-02



MC 420
with 5 position
encoder inputs

HDR hard disk

The HDR hard disk is removable. It contains the NC software and a slot for the SIK component.

HDR for	ID
MANUALplus 620	628935-51



HDR hard disk

SIK component

The SIK component contains the **NC software license** for enabling control loops and software options. It gives the main computer an unambiguous ID code—the SIK number. The SIK component is ordered and shipped separately. It must be inserted in a special slot in the HDR.

Additional control loops and options can be enabled later by entering a keyword. HEIDENHAIN provides the keyword, which is based on the SIK number. When ordering, please indicate the SIK number of your control.

When the keywords are entered in the control, they are saved in the SIK component. This enables and activates the options.



SIK component

Master keyword For commissioning the MANUALplus 620, a master keyword can be used that will unlock all options for a duration of two weeks. After this period, the control loop options can only be activated through the correct keyword. Should service become necessary, the SIK component must be inserted in the replacement control to enable all required options.

NC software license	SIK with software license and enabling for	ID
	3 control loops	In preparation
	3 control loops and cycle programming option (option 8)	In preparation
	3 control loops, cycle programming option (option 8), smart.Turn (option 9) and C axis (option 55)	530005-53

Additional axes	Option number	ID
1st additional axis (4th control loop)	0	354540-01
2nd additional axis (5th control loop)	1	353904-01

Software options The features of the MC 420 can also be adapted with options retroactively to meet new requirements. These options are described on page 10. They are enabled by entering keywords based on the SIK number, and are saved in the SIK component. Please indicate your SIK number when ordering new options.

Controller Unit

Controller unit

The **CC 422** controller unit includes:

- Speed controller
- Current controller
- Interfaces to the UM 1xx, UR 2xx, and UE 2xx power modules (PWM outputs)
- Interfaces to the shaft speed encoders
- Interfaces for power supply for controller unit and main computer (supply via UVR 1xxD, UE 2xxD or UR 2xx)

CC 422

The CC 422 is available with max. 6 digital control loops.

The number of enabled control loops is saved in the SIK (see *Main Computer*).

The CC 422 controller unit is combined with the MC 420 main computer. The position controllers and position encoder inputs are located on the MC 420 main computer (version with 5 position encoder inputs).



CC 422

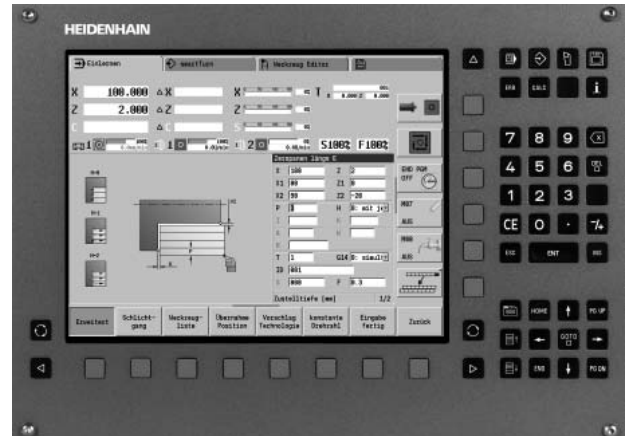
CC 422	Max. 6 digital control loops
Speed inputs	6 x 1 V _{PP} or EnDat 2.1
PWM outputs	6
Weight	4.0 kg
ID	359651-xx

Operating Panel

BFT 131 Operating Panel

ID 583683-01
Weight (approx.) 3 kg

- 12.1-inch color flat-panel display (1024 x 768)
- Operating mode keys
- Horizontal and vertical soft keys
- Numeric keypad
- Editing keys
- smart.Turn keys

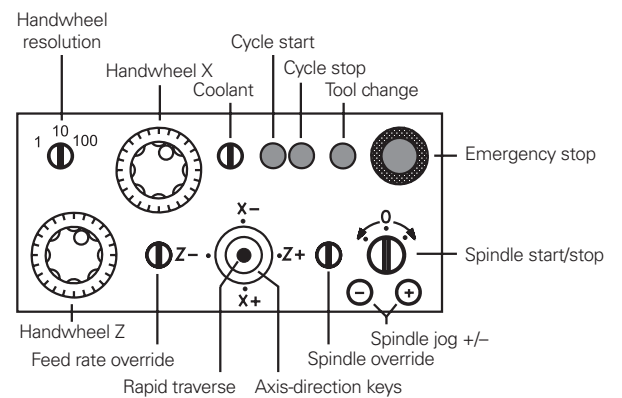


BFT 131

Machine operating panel

The machine tool builder designs the machine operating panel. It should contain the following components:

- Handwheels
- Axis-direction buttons or joystick
- Emergency-stop button
- Feed rate override
- Spindle override
- Cycle keys
- Spindle keys



Proposal for a machine operating panel

Accessories

PLC Inputs/Outputs

PL 510

If the PLC inputs/outputs of the MC do not suffice, additional PL 510 PLC input/output units can be connected. These external modular I/O systems consist of a basic module and one or more input/output modules.

Basic modules

Basic modules are available for 4, 6 or 8 I/O modules. They are mounted on standard NS 35 rails (DIN 46227 or EN 50022).

Supply voltage	24 V–
Power consumption (approx.)	20 W
Weight	0.36 kg (bare)

Basic modules with HEIDENHAIN PLC interface

PLB 510	Slots for 4 I/O modules	ID 358849-01
PLB 511	Slots for 6 I/O modules	ID 556941-01
PLB 512	Slots for 8 I/O modules	ID 557125-01

Up to four PLB 510 and up to two PLB 511 or PLB 512 can be connected to the control. The maximum cable length to the last PLB 51x is 30 meters.

I/O modules

The I/O modules consist of one module with digital inputs/outputs and one analog module. For partially assembled basic modules, the unused slots must be occupied by an empty housing.

PLD 16-8

I/O module with 16 digital inputs and 8 digital outputs

Total current	Outputs 0 to 7:	≤ 4 A
	Outputs 0 to 3, or 4 to 7:	≤ 2 A
Simultaneity factor:	2 outputs:	2 A each
	4 outputs:	1 A each
	8 outputs:	0.5 A each
Weight	0.2 kg	
ID	360916-01	

PLA 4-4

Analog module with
4 analog inputs for PT 100 thermistors
4 analog inputs for ± 10 V

Weight	0.2 kg
ID	366423-01

Empty housing

For unused slots	
ID	383022-01



PL 510

Electronic Handwheels

The standard MANUALplus 620 supports the use of electronic handwheels.

The following handwheels can be installed:

- For connection to position inputs
Up to two **HR 180**
- For connection to the handwheel input
One **HR 410** portable handwheel, or
One **HR 130 panel-mounted handwheel**

Any combination is possible: cycle machines typically use two HR 180 and—depending on the needs—an HR 140 or simply an HR 130 for CNC machines.

Function

- Incremental movement of the slide:
1 μm /10 μm /100 μm per increment
- The handwheels with detent have 100 stops per revolution
- Positioning the slide to the starting position of MANUALplus cycles
- Fine adjustment of tool position

HR 180

Panel-mounted handwheel with ergonomic control knob for connection to a position encoder input.

Weight (approx.)	0.7 kg
HR 180 with detent	ID 540940-08

HR 130

Panel-mounted handwheel with ergonomic control knob for connection to the handwheel input. It is connected to the logic unit directly or via extension cable.

Weight (approx.)	0.7 kg
HR 130 without detent	ID 254040-05
HR 130 with detent	ID 540940-01

HR 410

Portable handwheel for connection to the handwheel input with

- Keys for the selection of 5 axes
- Traverse direction keys
- Keys for three preset feed rates (PLC function)
- Actual-position-capture key
- Three keys with machine functions (see below)
- Two permissive buttons (24 V)
- Emergency stop button (24 V)
- Magnetic holding pads
- Weight approx. 1 kg

All keys are designed as snap-on keys and can be replaced by keys with other symbols.

HR 410 (NC start/stop, spindle start; for PLC basic program) without detent	ID 296469-55
with detent	ID 535220-05

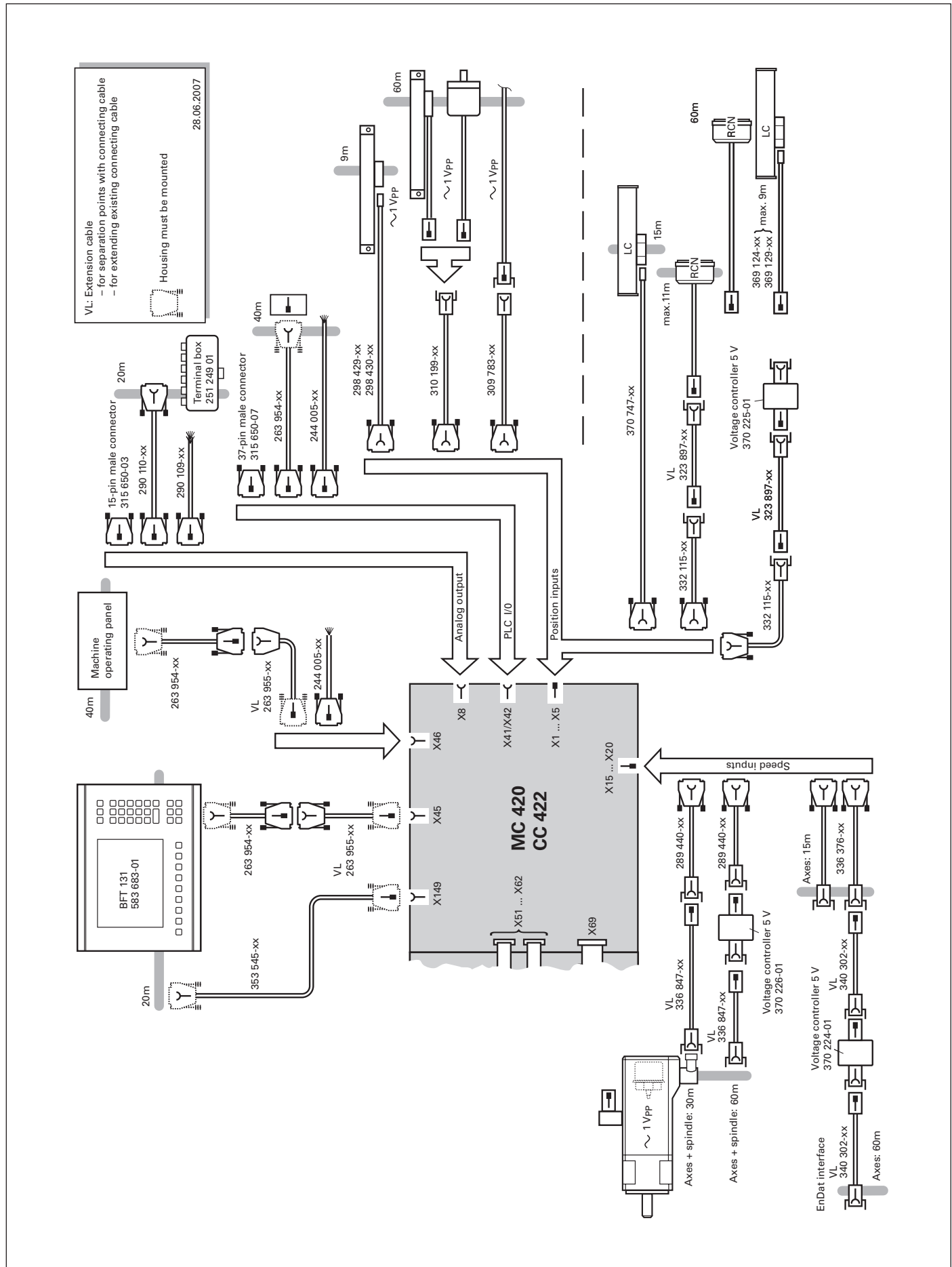
HR 410 (spindle right/left/stop) without detent	ID 296469-54
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Connecting cable (spiral) to HR 410 (3 m)	ID 312879-01
HR 410 / MC 422 adapter cable	ID 296466-xx
Dummy plug for emergency stop circuit	ID 271958-03

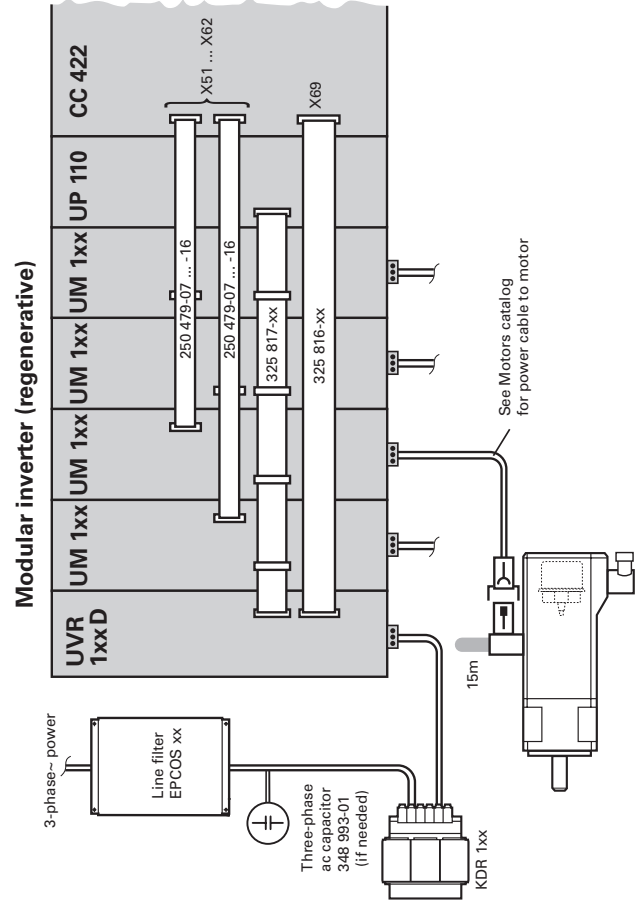
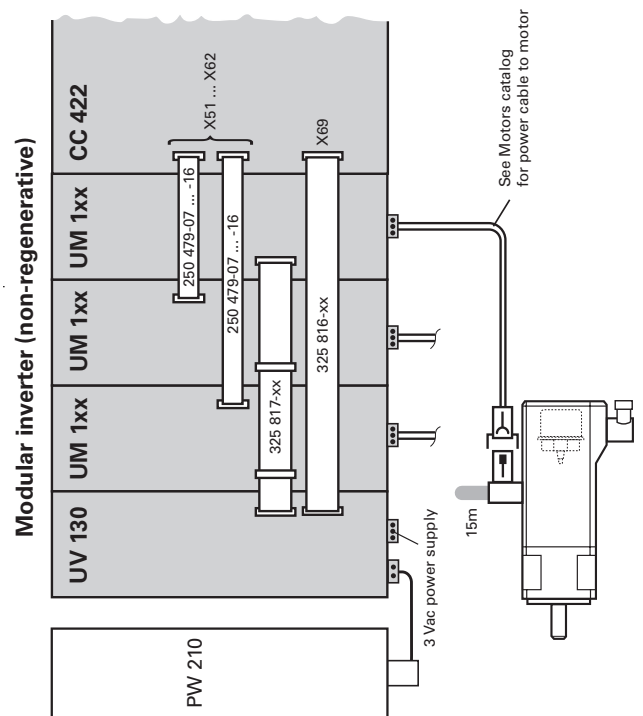
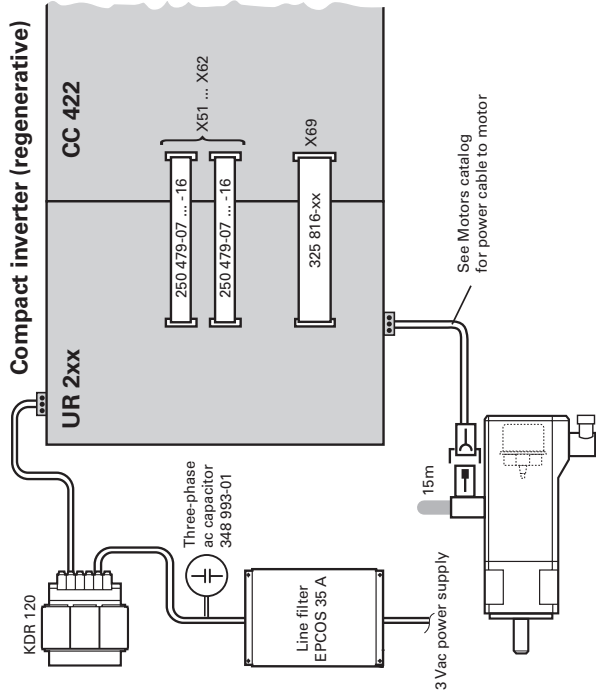
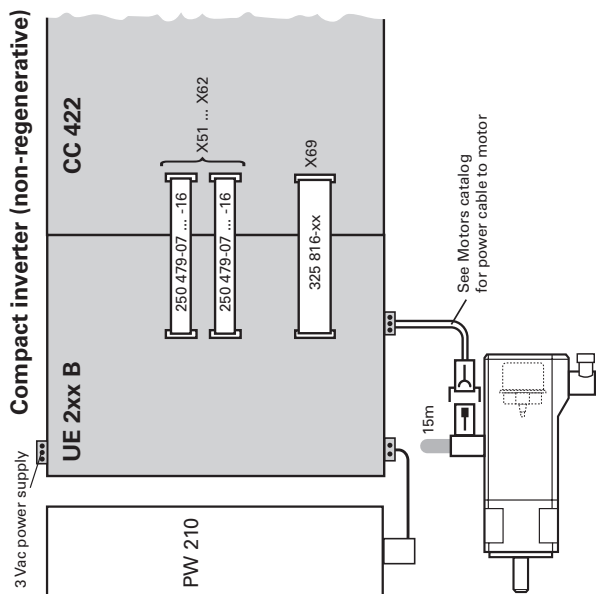


Cable Overviews

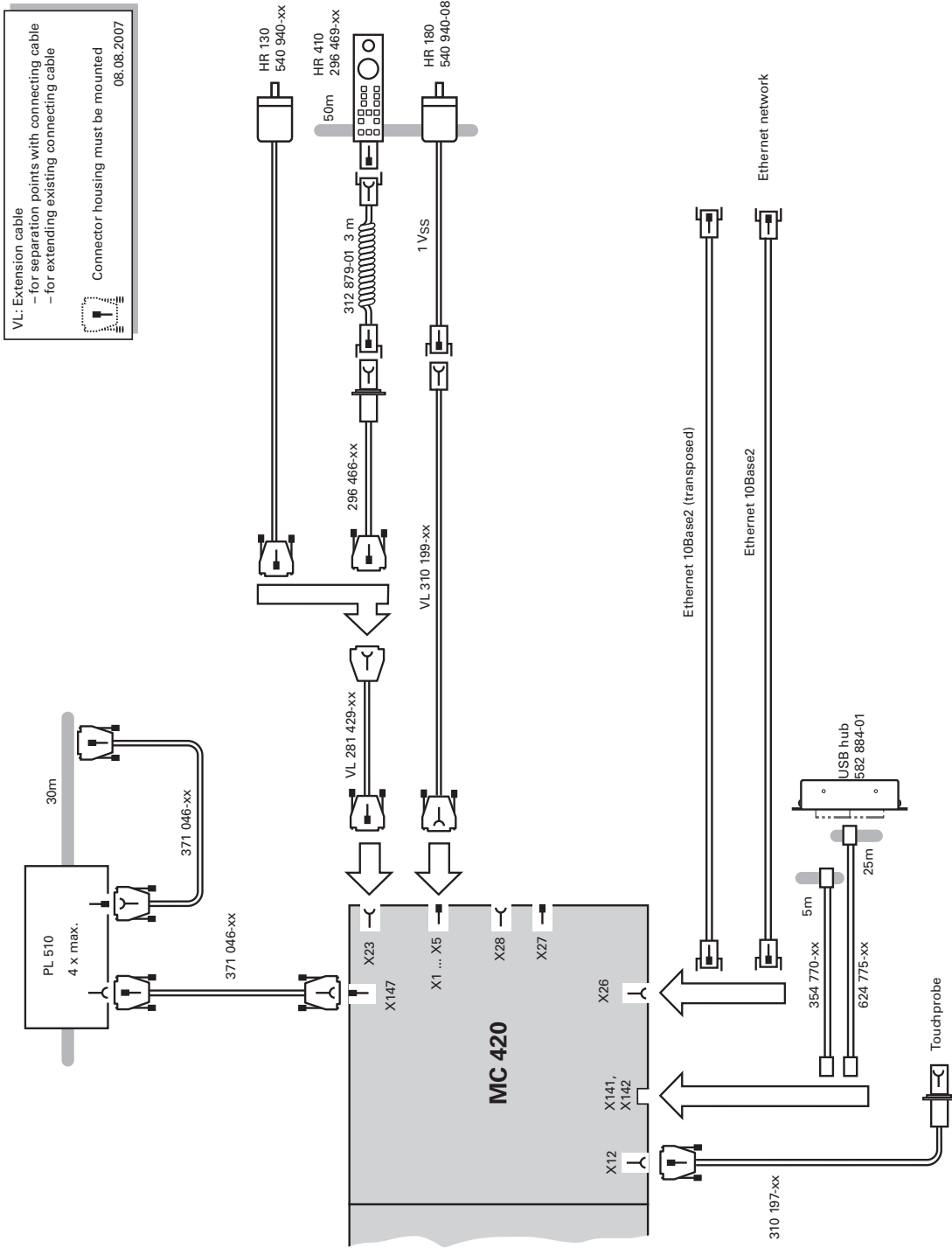
Control Systems



Inverter Systems



Accessories



MANUALplus 620

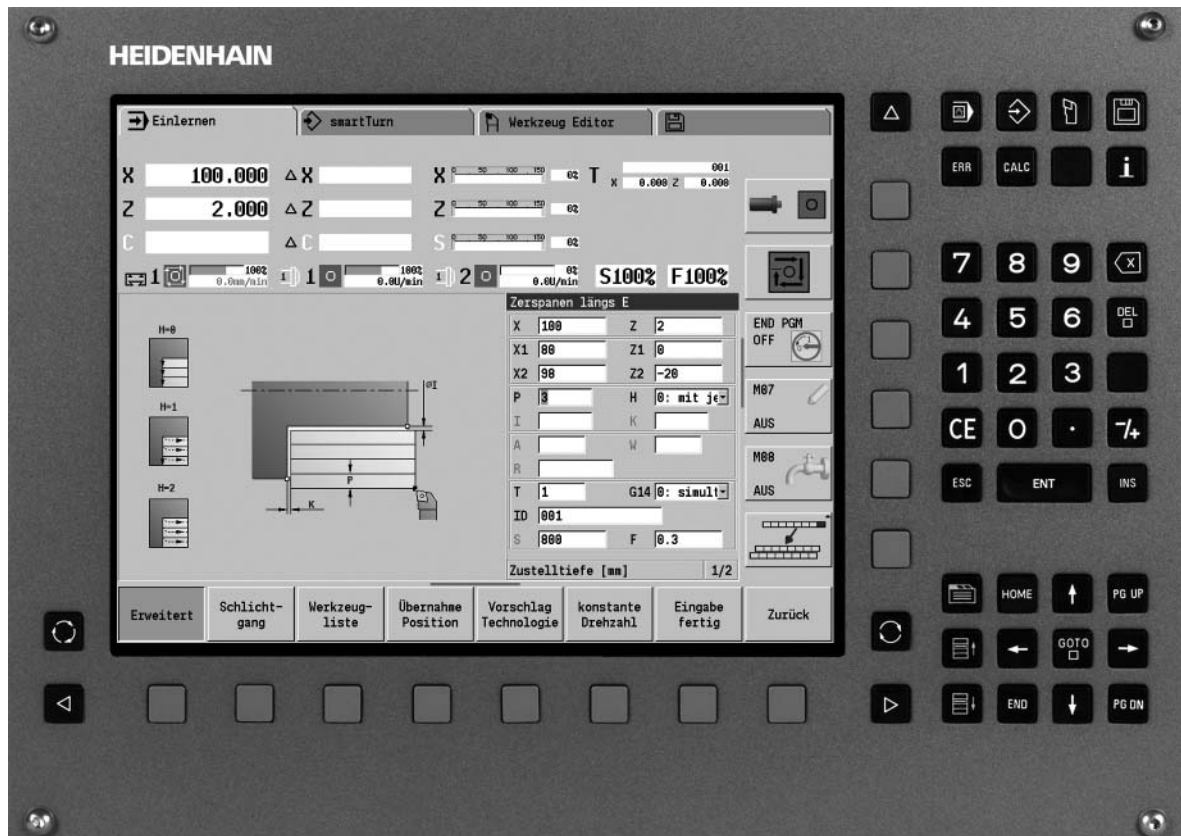
The Contouring Control for Lathes and Cycle Lathes

The MANUALplus 620 for cycle lathes

- Conceived for general repairs, thread repairs, single parts and short production runs
- Supports action-oriented machining
- Quickly learned—requires minimum training time
- Supports boring, drilling and milling operations on the face and lateral surface
- Features a wide machining spectrum, from simple turned parts to complex workpieces

The MANUALplus 620 for CNC lathes

- Conceived for medium-sized and large production runs
- Programming via smart.Turn and/or DIN PLUS
- smart.Turn is quickly learned and requires very little training time
- Supports boring, drilling and milling operations on the face and lateral surface
- Features a wide machining spectrum, from simple turned parts to complex workpieces



Technical Description

Axes

The MANUALplus 620 is a contouring control for manual lathes with one spindle and a compound rest (X and Z) for tool movement. The MANUALplus supports both horizontal and vertical lathes.

Display and programming

Feed rate in

- mm/min
- mm/revolution
- Feed rate override: 0 to 150%
- Maximum feed rate at $f_{PWM} = 5000$ Hz:

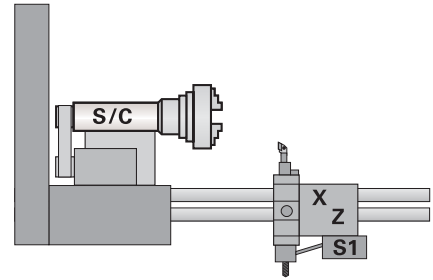
$$\frac{60000 \text{ min}^{-1}}{\text{No. of pole pairs in motor}} \cdot \text{screw pitch [mm]}$$

Traverse range

-99999.9999 to +99999.9999 [mm]
 The machine tool builder defines the traverse range. It is also possible for the operator to limit the traverse range if he wishes to reduce the working space (with software limit switches). A protection zone for the spindle (Z-) can also be specified.

Tool carriers

The MANUALplus 620 supports simple tool holders (multipoint tools) and tool turrets. The tool carriers can be located in front of or behind the workpiece.



Main Spindle

For machines featuring a higher level of automation, you can position the spindle or switch to C-axis operation.

Display and programming

- Spindle speed:
- Constant shaft speed: 1 to 99999 rpm
 - Constant surface speed: 1 to 9999 m/min

Spindle positioning

Input resolution and display step: 0.001°

Spindle override

50 to 150%

Maximum speed

$$n_{\max} = \frac{f_{PWM} \cdot 60000 \text{ min}^{-1}}{NPP \cdot 5000 \text{ Hz}}$$

f_{PWM} = PWM frequency in Hz

NPP = Number of pole pairs

Speed limiting

- The MANUALplus monitors the actual speed.
- Speed limiting can be adjusted via parameter and in the feed rate/spindle/tool menu.

Gear stages

A specific parameter can be defined for each gear range. The gear is switched via the PLC.

C-axis operation

For milling, drilling and boring cycles, either the spindle is switched to C-axis operation or a separate C-axis drive is activated.

Input resolution and display step: 0.001°

Driven Tool

The driven tool is used for drilling and tapping holes as well as for milling in M19 or C-axis operation. Programs for the driven tool can be input in manual operation, via cycles with smart.Turn or in the DIN editor.

Display and programming

Speed of the driven tool:

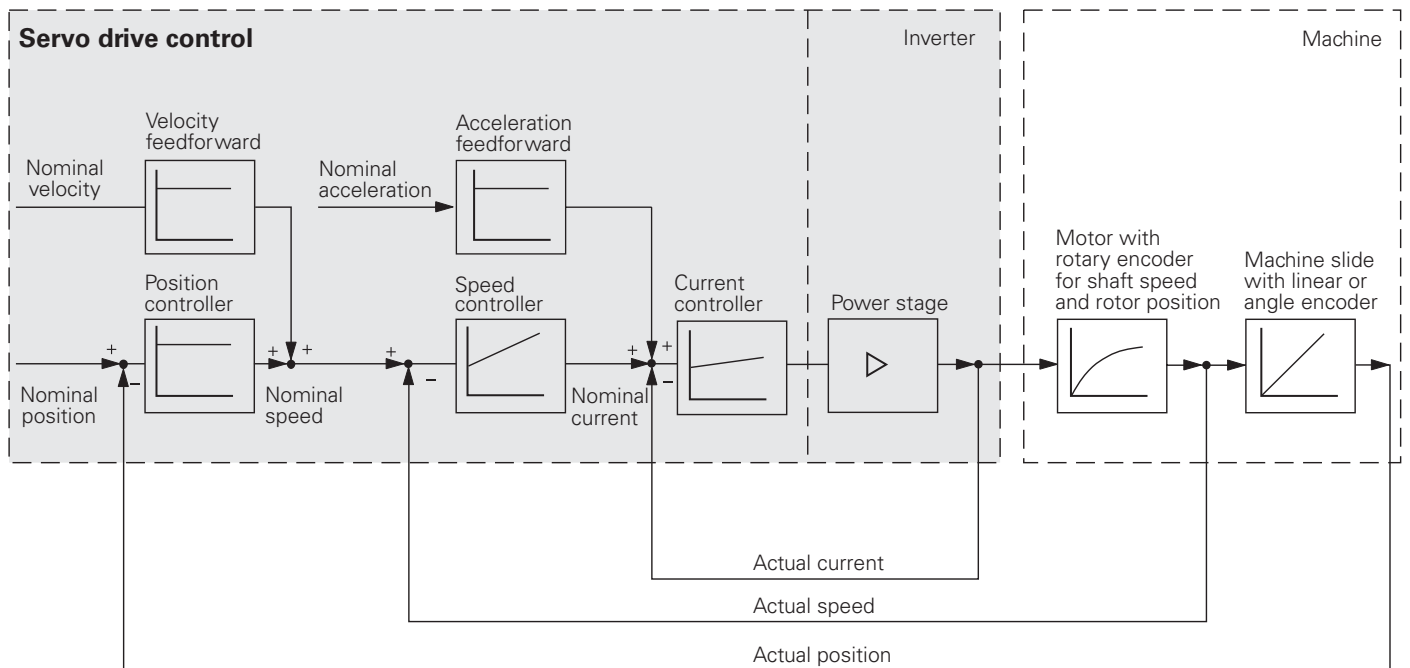
- Constant shaft speed: 1 to 99999 rpm
- Constant surface speed: 1 to 9999 m/min

Speed limiting

- The MANUALplus monitors the actual speed.
- Speed limiting can be adjusted via parameter and in the feed rate/spindle/tool menu.

Digital Control

Integrated inverters Position controllers, speed controllers, current controllers and inverters are integrated in the control. HEIDENHAIN synchronous and asynchronous motors are connected to the MANUALplus 620.



Axis feedback control

The MANUALplus 620 operates with feedforward control.

Operation with following error (servo lag)

The term "following error" denotes the distance between the momentary nominal position and the actual position of the axis.

The velocity is calculated as follows:

$$v = k_v \cdot s_a$$

v = velocity
 k_v = loop gain
 s_a = following error

Operation with feedforward control

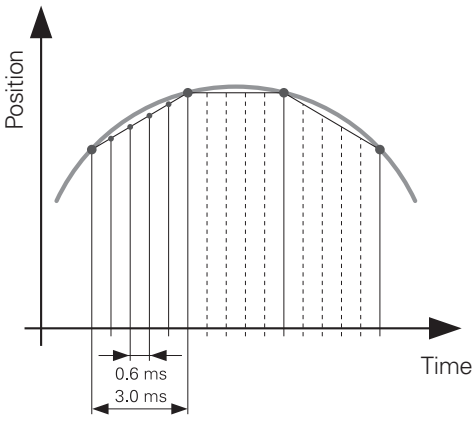
Feedforward control means that the speed and the acceleration are preset according to the machine, while taking the jerk limiting into account. Together with the values calculated from the following error, it forms the nominal value. In this way, the following error becomes very small (in the range of a few μm). The feedforward is adjustable from 0 to 100% via a machine parameter.

Control loop cycle times

The **position controller** cycle time is the time interval in which the actual position value is compared to the calculated nominal position value.

The **speed controller** cycle time is the time interval in which the actual speed value is compared to the calculated nominal speed value. The cycle time for the **current controller** is defined as the time interval during which the actual current value is compared to the calculated nominal current value.

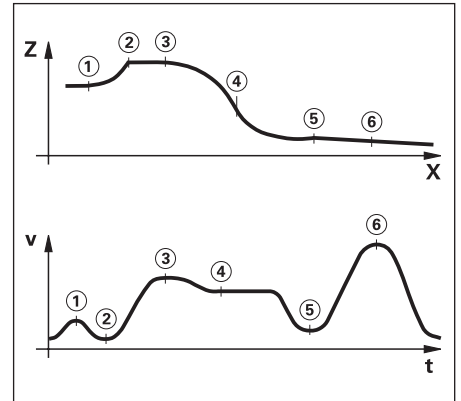
	Position controller	Speed controller	Current controller
MC 420	3 ms	0.6 ms	0.1 ms
CC 422			



Fast Machining

Look-ahead

The MANUALplus 620 calculates the geometry ahead of time in order to adjust the feed rate. In this way directional changes are detected in time to accelerate or decelerate the appropriate NC axes.



Jerk Limiting

Jerk

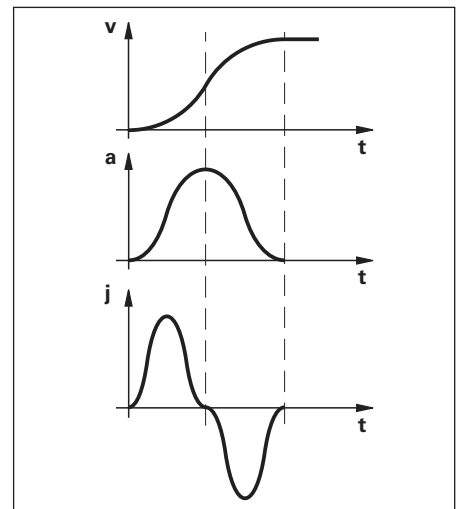
The derivative of acceleration is referred to as jerk. A linear change in acceleration causes a jerk step. This jerk causes oscillations, and leads to contour damage.

Jerk limiting

To prevent machine oscillations, the jerk is limited to attain optimum path control. The MANUALplus 620 machines smooth surfaces at the highest possible feed rate, and yet keeps the contour accurate. The machine manufacturer sets the permissible tolerance via parameter.

Jerk smoothing

The jerk is smoothed by a nominal position value filter. The MANUALplus 620 machines smooth surfaces at the highest possible feed rate. The machine manufacturer sets the permissible tolerance via parameter.



Encoders

For speed and position control of the axes and spindle, HEIDENHAIN offers both incremental as well as absolute measuring systems.

Incremental encoders

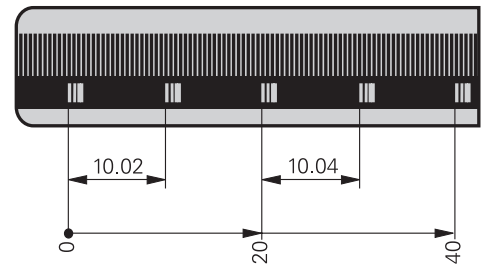
Incremental encoders have as measuring standard a grating consisting of alternate lines and spaces. Relative movement between the scanning head and the scale causes output of sinusoidal scanning signals. The measured value is calculated from these signals.

Reference mark

When the machine is switched on, the machine axes need to traverse a reference mark for an accurate reference to be established between measured value and machine position. For encoders with distance-coded reference marks, the maximum travel until automatic reference mark evaluation for linear encoders is only 20 mm or 80 mm, depending on the model, or 10° or 20° for angle encoders.

Output signals

Incremental encoders with sinusoidal output signals with $\sim 1 V_{PP}$ levels are suitable for connection to HEIDENHAIN numerical controls.



Absolute encoders

With absolute encoders, the position information is mapped in several coded tracks. Thus, an absolute reference is available immediately after switch-on. There is no need to scan a reference mark. Additional incremental signals are output for highly dynamic control loops.

EnDat interface

The MANUALplus 620 is fitted with the serial EnDat 2.1 interface for the connection of absolute encoders.

Note: The EnDat interface on HEIDENHAIN encoders differs in its pin assignment from the interface on Siemens motors with integrated absolute ECN/EQN rotary encoders. Special adapter cables are available.

Encoder inputs for position control

Incremental and absolute linear, angle or rotary encoders from HEIDENHAIN can be connected to all position encoder inputs of the MC 420.

Inputs	Signal level/ Interface ¹⁾	Input frequency ¹⁾
Incremental	~ 1 V _{PP}	33 kHz/350 kHz
Absolute	EnDat 2.1 ~ 1 V _{PP}	– 33 kHz/350 kHz

¹⁾ Switchable

Encoder inputs for speed control

Incremental and absolute rotary encoders from HEIDENHAIN can be connected to all speed encoder inputs of the CC 422.

Inputs	Signal level/ Interface ¹⁾	Input frequency
Incremental	~ 1 V _{PP}	350 kHz
Absolute	EnDat 2.1 ~ 1 V _{PP}	– 350 kHz

¹⁾ Switchable

Error Compensation

The MANUALplus 620 features functions for automatic compensation of mechanical errors of the machine.

Linear error	Linear error can be compensated over the entire travel range for each axis.
Nonlinear error	The MANUALplus 620 compensates axis error and error that depends on the positions of other axes (ball screw pitch error, axis sag, misaligned axes, etc.).
Backlash	For length measurements via spindle and rotary encoders, the play between the table movement and the rotary encoder movement on direction changes can be compensated. This backlash is outside the controlled system.
Hysteresis	The hysteresis between the table movement and the motor movement is also compensated in length measurements. In this case the hysteresis is within the controlled system.
Reversal peaks	In circular movements, reversal peaks can occur at quadrant transitions due to mechanical influences. The MANUALplus 620 can compensate for these reversal peaks.
Stick-slip friction	High static friction can lead to stick-slip: the slide stops and starts repeatedly for short periods at low feed rates. This is also known as stiction. The MANUALplus 620 can compensate for this problem condition.
Thermal expansion	<p>To compensate thermal expansion, the machine expansion behavior must be known.</p> <p>The temperature can be recorded via temperature measurement thermistors connected to the analog inputs of the MANUALplus 620. The PLC evaluates the temperature information and transfers the compensation value to the NC.</p>

Integrated PLC

The PLC program is created by the machine manufacturer either with the PLC development software **PLCdesignNT (accessory)** or at the control with an external PC keyboard with a USB connection.

Machine-specific functions are activated and monitored via the PLC inputs/outputs. The number of PLC inputs/outputs required depends on the complexity of the machine.

PLC expansion	If the PLC inputs/outputs of the MC 420 do not suffice, the external PL 510 PLC input/output system can be connected.	
Rated operating current per output	Logic unit:	0.15 A (For PL 5xx see <i>PLC Inputs/Outputs</i>)
PLC programming	Format	Statement list
	Memory	<ul style="list-style-type: none">• PLC program: on hard disk• Process memory: 512 KB RAM• Data memory: 124 KB RAM
	Cycle time	18 ms, adjustable
	Instruction set	<ul style="list-style-type: none">• Bit, byte and word commands• Logical operations• Arithmetic instructions• Comparisons• Parenthetic calculations• Jump commands• Subprograms• Stack operations• Submit programs• 999 timers• 48 counters• Comments• PLC modules• 100 strings
PLC soft keys	The machine manufacturer can display his own PLC soft keys in the vertical soft-key row on the screen.	
PLC positioning	All closed-loop axes can be positioned via the PLC. PLC positioning of the NC axes cannot be superimposed on NC positioning.	
PLC axes	Axes can be controlled by the PLC. They are programmed via M functions or OEM cycles. The PLC axes are positioned independently of the NC axes.	

PLCdesignNT
(accessory)

PC software for PLC program development.
The PC program **PLCdesignNT** can be used for easy creation of PLC programs. Comprehensive examples of PLC programs are included.

Functions:

- Easy-to-use text editor
- Menu-guided operation
- Programming of symbolic operands
- Modular programming method
- "Compiling" and "linking" of PLC source files
- Operand commenting, creation of a documentation file
- Comprehensive help system
- Data transfer between personal computer and MANUALplus 620
- Creation of PLC soft keys

PC requirements:

- Operating system Windows 98/NT/2000/ME/XP
- Compatible computer, Pentium 133 or higher
- At least 32 MB RAM
- Minimum 20 MB free memory on the hard disk
- At least VGA
- Serial interface; Ethernet interface recommended
- Internet Explorer 4.01 or higher

PLC basic program

The PLC basic program serves as a basis for adapting the MANUALplus 620 to the requirements of the respective machine. Registered customers can download it from the Internet.

The following functions are covered by the PLC basic program:

- Controlling all axes
- Positioning the axes after the reference run
- Clamped axes
- Homing the axes, reference end positions
- Temperature compensation of the axes
- Feed rate control
- Controlling and orienting the spindle
- Spindle brake
- Gear switching via M functions
- C axis via main drive
- C axis via separate drive¹⁾
- PLC soft keys
- Displaying and managing PLC error messages
- Hydraulic control¹⁾
- Hydraulic chuck¹⁾
- Electronic handwheels
- Controlling the coolant system¹⁾
- Handling of M and G functions
- Lubrication¹⁾
- Chip conveyor¹⁾
- Door control¹⁾
- Tool change for multipoint tools¹⁾
- Positioning of the tool turret with three-phase motor¹⁾

¹⁾ Basic functions are implemented

Commissioning and Diagnostic Aids

The MANUALplus 620 provides internal commissioning and diagnostic aids.

Oscilloscope

The MANUALplus 620 features an integrated oscilloscope. Both X/t and X/Y graphs are possible. The following characteristic curves can be recorded and saved in six channels:

- Actual value of axis feed rate
- Nominal value of axis feed rate
- Contouring feed rate
- Actual position
- Nominal position
- Servo lag of the position controller
- Nominal values for speed, acceleration and jerk
- Actual values for speed, acceleration and jerk
- Nominal value of analog output
- Content of PLC operands
- Encoder signal (0° – A)
- Encoder signal (90° – B)

Logic signals

Simultaneous graphic representation of the logic states of up to 16 operands (markers, words, inputs, outputs, counters, timers)

- Marker (M)
- Input (I)
- Output (O)
- Timer (T)
- Counter (C)
- IpoLogik (X)

TNCscopeNT (accessory)

PC software for transferring the oscilloscope files to the PC.
Note: The trace files are saved in the TNCscopeNT data format.

Table function

The current conditions of the markers, words, inputs, outputs, counters and timers are displayed in tables. The conditions can be changed via the keyboard.

Trace function

The current content of the operands and the accumulators is shown in the statement list in each line in hexadecimal or decimal code. The active lines of the statement list are marked.

Log

For the purposes of error diagnosis, there is one log for all error messages and one for all keystrokes.

TNCopt (accessory) PC software for commissioning digital control loops

Functions:

- Commissioning the current controller
- (Automatic) commissioning of the speed controller
- (Automatic) optimization of sliding-friction compensation
- (Automatic) optimization of the reversal-spike compensation
- (Automatic) optimization of k_V factor

Requirements:

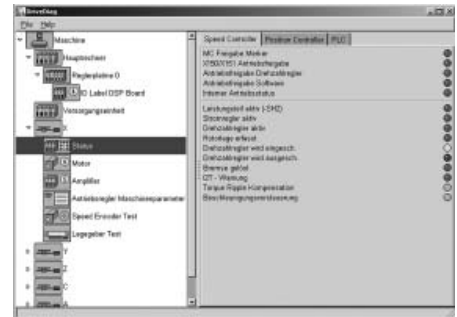
- Windows 95/98 or NT 4.0 or 2000 operating system
- At least VGA—XGA recommended
- At least 16 MB RAM
- At least 15 MB of free hard-disk space
- Ethernet interface

DriveDiag
(accessory)

The DriveDiag software for PCs enables the service technician to make a simple and fast diagnosis of the drives. It also permits the display and evaluation of the electronic ID labels.

The following diagnostic functions are available:

- Reading and displaying the electronic ID labels of QSY motors with EQN 1325 or ECN 1313
- Reading and displaying the electronic ID labels of the UVR 1xxD and UM 1xxD inverter modules
- Displaying and evaluating the internal control conditions and the status signals of the inverter components
- Displaying the analog values available to the drive controller
- Automatic test for proper function of motors and inverters
- Automatic test of position and speed encoders



OLM
Online monitor

The online monitor (OLM) supports the commissioning and diagnosis of control components through:

- Display of control-internal variables for axes and channels
- Display of controller-internal variables
- Display of hardware signal states
- Various trace functions
- Activation of spindle commands
- Enabling control-internal debug outputs

The online monitor is a component part of the control and is called over a code number.

Monitoring Functions

During operation, the MANUALplus 620 monitors:

- Amplitude of the encoder signals
- Edge separation of the encoder signals
- Absolute position for encoders with distance-coded reference marks
- Current position (servo lag monitoring)
- Actual path traversed (movement monitoring)
- Position deviation at standstill
- Nominal speed value
- Checksum of safety-related functions
- Supply voltage
- Buffer battery voltage
- Operating temperature of the MC and CPU
- Running time of the PLC program
- Motor current
- Motor temperature
- Temperature of power module
- DC-link voltage

Hazardous errors trigger an EMERGENCY STOP message that is sent to the external electronics via the control-is-ready output, and the axes are brought to a stop. The correct connection of the MANUALplus 620 into the machine's EMERGENCY STOP loop is checked when the control system is switched on.

In the event of an error, the MANUALplus 620 displays a message in plain language.

Data Interfaces

The MANUALplus 620 is connected to PCs, networks and other data storage devices via data interfaces.

Ethernet

The MANUALplus 620 can be interconnected via the Ethernet interface. The MANUALplus 620 features a 100BaseT Ethernet (Twisted Pair Ethernet) connection to the data network.

Maximum transmission distance:
Unshielded 100 m
Shielded 400 m

Protocol The MANUALplus 620 communicates using the TCP/IP protocol.

Network connection

- NFS file server
- Windows networks (SMB)

Data transfer rate Approx. 40 to 80 Mbps (depending on file type and network utilization)

RS-232-C/V.24

Data interface according to DIN 66020 or EIA standard RS-232-C.
Maximum transmission distance: 20 m

RS-422/V.11

Data interface according to EIA standard RS-422.
Maximum transmission distance: 1 km

The V.24 and V.11 interfaces can only be addressed by the PLC.

USB

The two USB interfaces are available for connecting standard storage media. They must not be loaded with a total supply current greater than 0.5 A. The maximum cable length for external USB units is 5 m without an amplifier. For lengths from 6 m, USB connecting cables with an integrated amplifier are required.

USB hub If you need further USB ports or if the supply current is not sufficient, a USB hub is required. The USB hub from HEIDENHAIN offers four free USB ports.

Power supply: 24 V- / max. 300 mA
ID 582884-01

Cover The USB hub can be installed in the operating panel in such a way that two USB ports can be accessed from the outside. An optionally available cover can be used to protect the ports from contamination.

ID 508921-01

Software for Data Transfer

TNCremoNT (accessory)

This PC software package helps the user to transfer data between the PC and the MANUALplus 620. The software is available free of charge on the HEIDENHAIN home page in the Services/Software area.

Functions:

- Data transfer
- File management
- Data backup
- Reading out the log
- Screen content, reading out
- Managing more than one machine

Requirements:

- Operating system Windows 95/98/ME/NT/2000/XP
- At least 10 MB free hard-disk space
- Ethernet interface

TNCremoPlus (accessory)

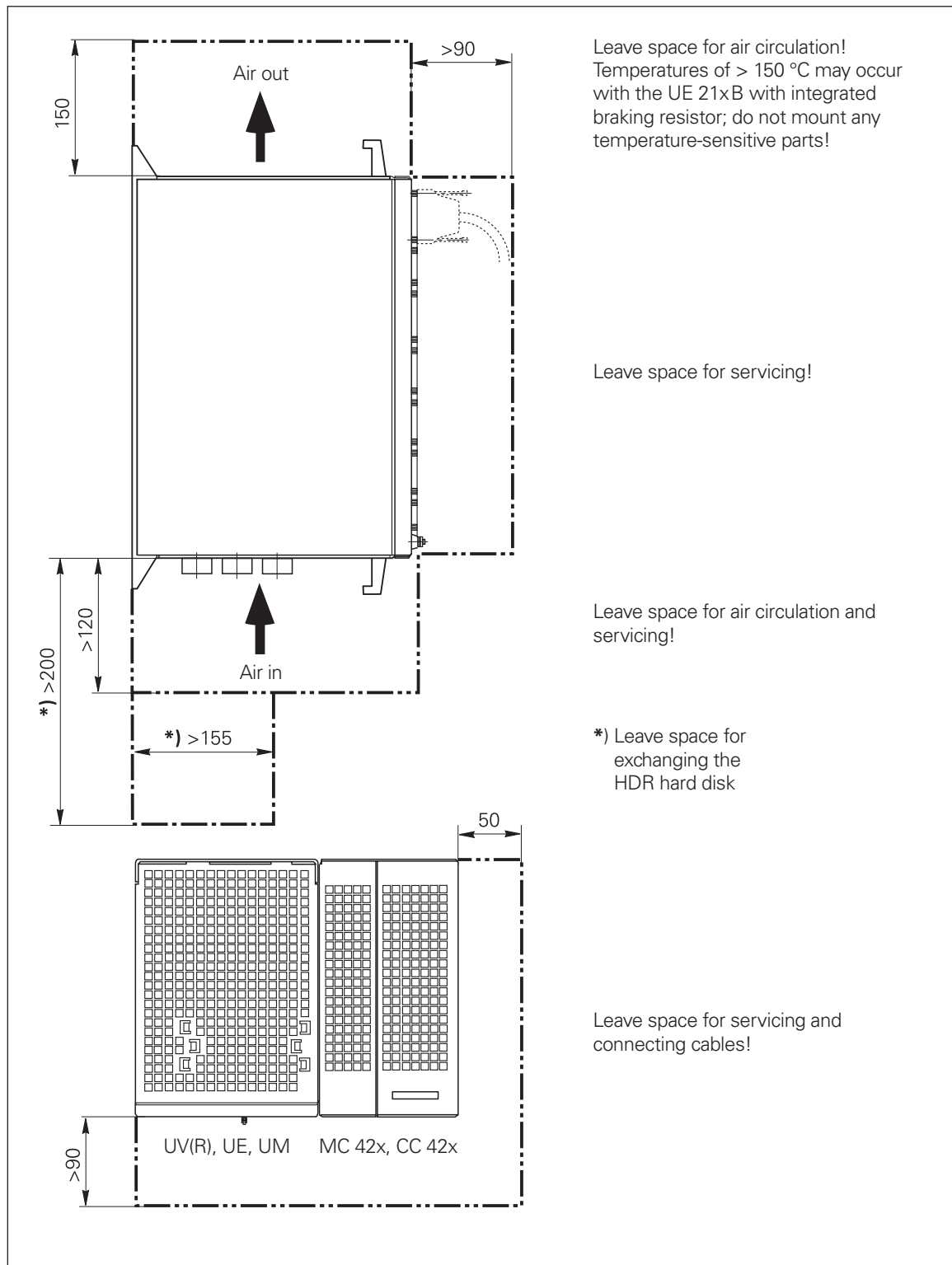
In addition to the features you are already familiar with from TNCremoNT, TNCremoPlus can also transfer the current content of the control's screen to the PC ("live screen"). This makes it very simple to monitor the machine.

ID

340447-xx

Mounting Instructions

Mounting attitude When installing the **MC 420, CC 422, UV(R) 1xx, UM xxx and UE 2xx,B** take note of the minimum spacing, space needed for servicing, and the appropriate length and location of the connecting cables.



Mounting and electrical installation

Keep the following in mind during mounting and electrical installation:

- National regulations for power installations
- Interference and noise immunity
- Conditions of operation
- Mounting attitude

Degrees of protection

The following components fulfill the requirements for IP 54 (dust protection and splash-proof protection):

- Visual display unit (when properly installed)
- Keyboard unit (when properly installed)
- Handwheel

Electromagnetic compatibility

Intended place of operation

The unit fulfills the requirements for a Class A device in accordance with the specifications in EN 55022, and is intended for use in industrially zoned areas.

Protect your equipment from interference by observing the rules and recommendations specified in the Technical Manual.

Likely sources of interference

Noise is mainly produced by capacitive and inductive coupling from electrical conductors or from device inputs/outputs, such as:

- Strong magnetic fields from transformers or electric motors
- Relays, contactors and solenoid valves
- High-frequency equipment, pulse equipment and stray magnetic fields from switch-mode power supplies
- Power lines and leads to the above equipment

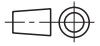
Protective measures

- Keep a minimum distance of 20 cm from the MC, CC and its leads to devices that carry interference signals.
- Keep a minimum distance of 10 cm from the MC, CC and its leads to cables that carry interference signals. For cables in metallic ducting, adequate decoupling can be achieved by using a grounded separation shield.
- Shielding according to EN 50178
- Use potential compensating lines with a cross section of 6 mm²
- Use only genuine HEIDENHAIN cables, connectors and couplings.

Overall Dimensions

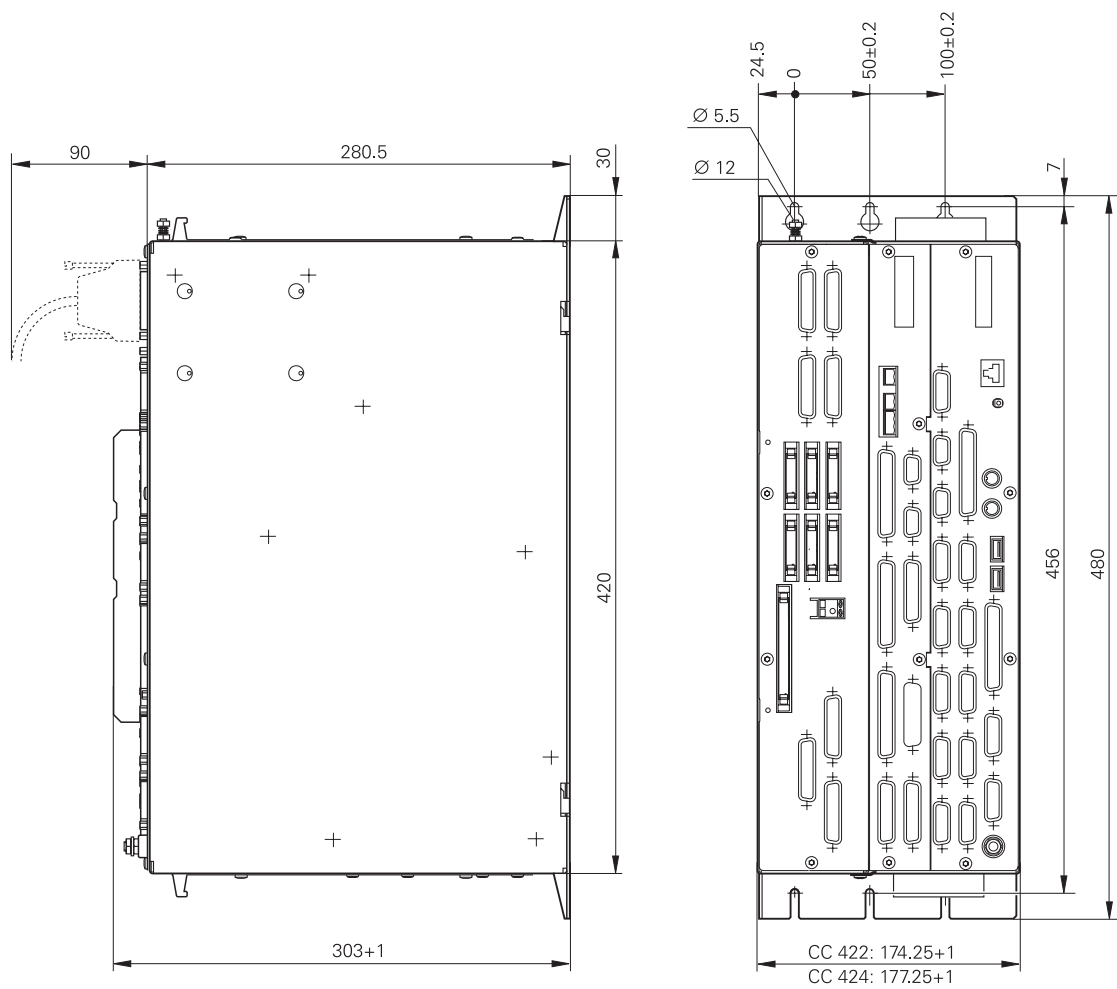
MC 420
CC 422

Dimensions in mm



Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ± 0.2 mm

MC 420 / 5 position encoder inputs
CC 422 / 6 control loops



BFT 131

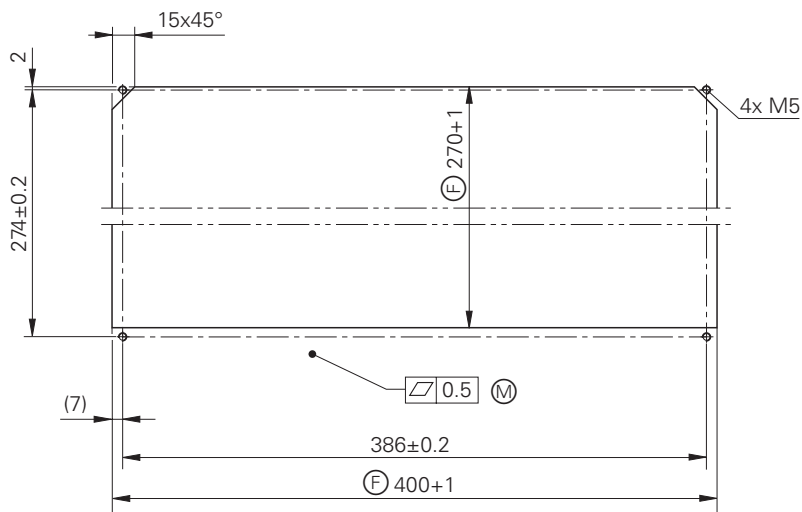
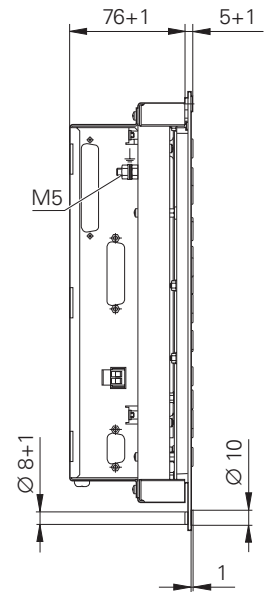
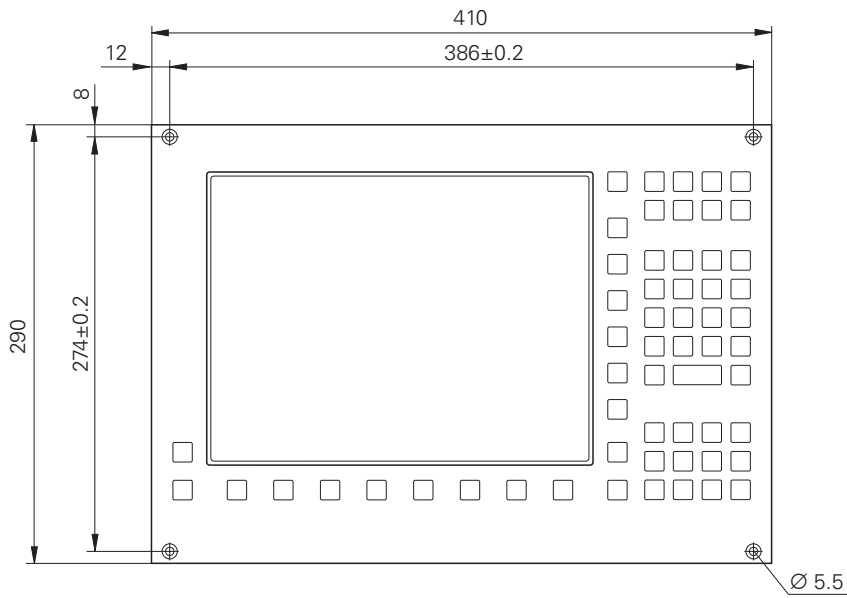
Dimensions in mm



Tolerancing ISO 8015

ISO 2768 - m H

< 6 mm: ± 0.2 mm

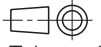


⊕ = Cutout in machine panel

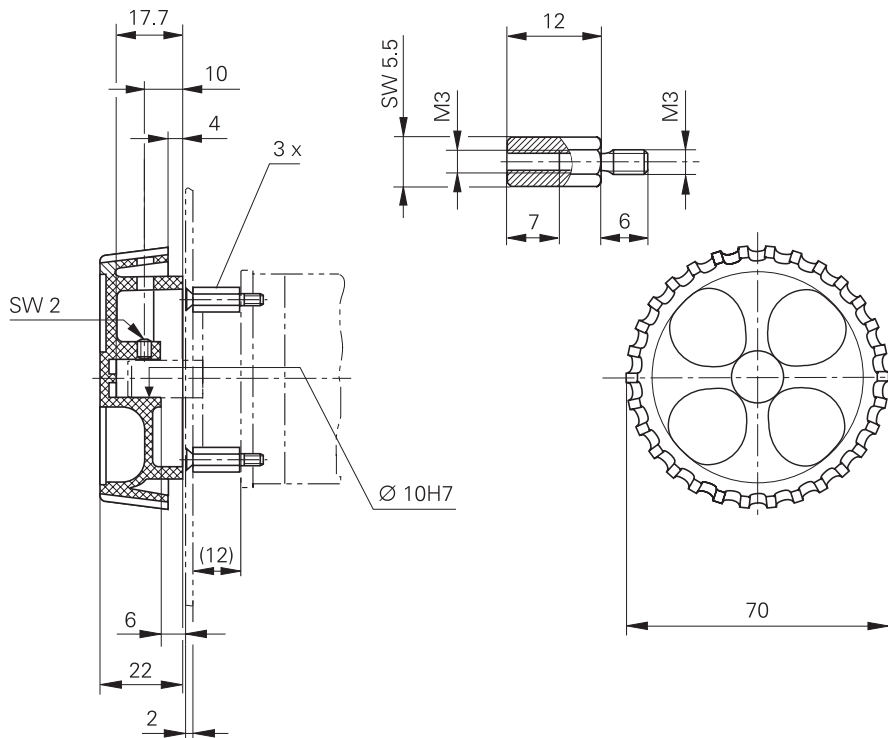
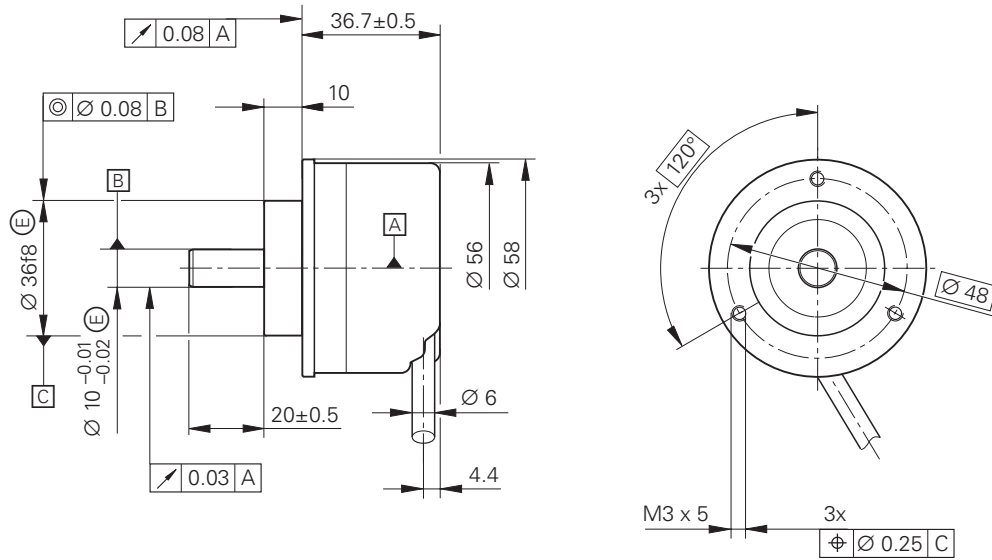
Ⓜ = Mounting surface

HR 130, HR 180 with Control Knob

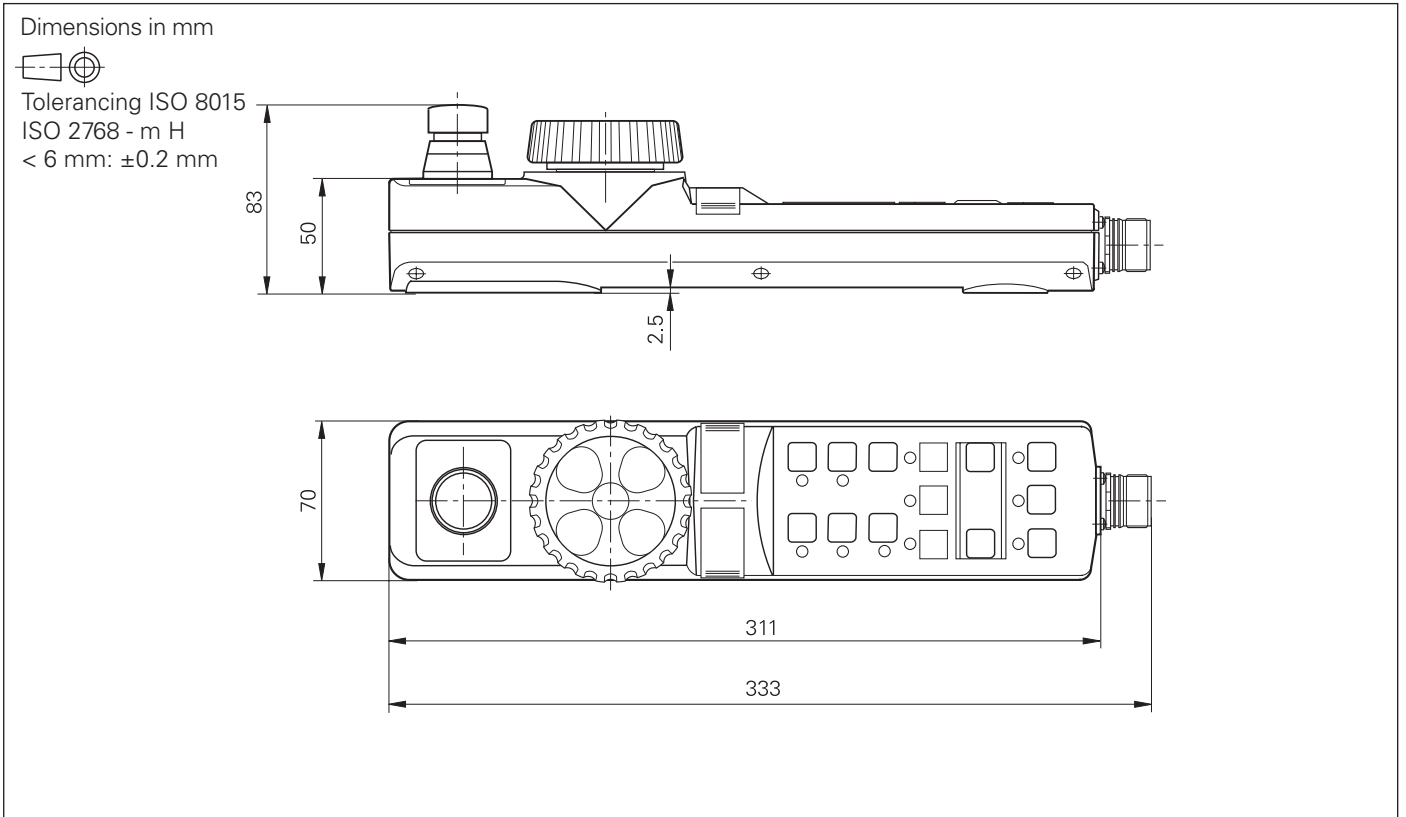
Dimensions in mm



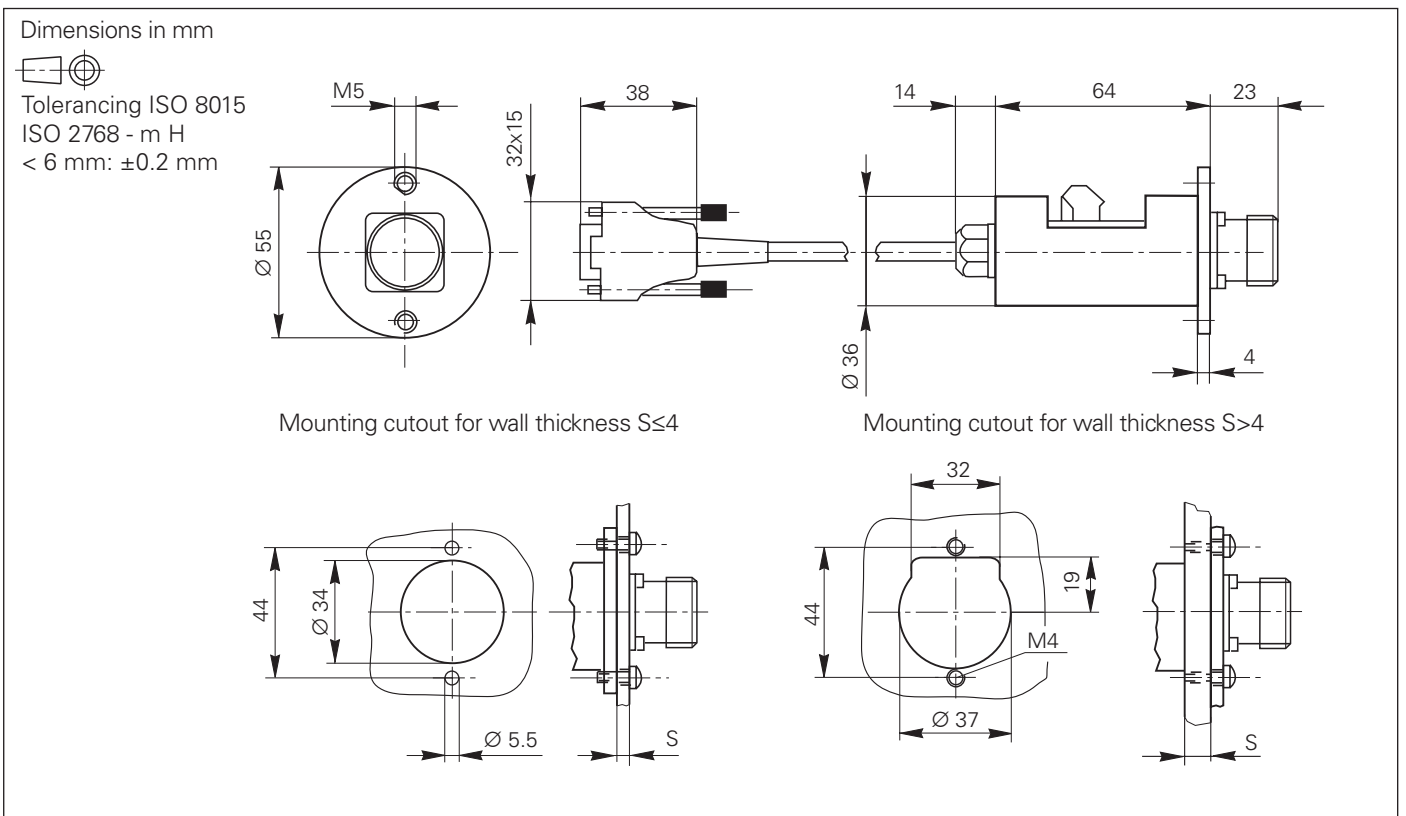
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm



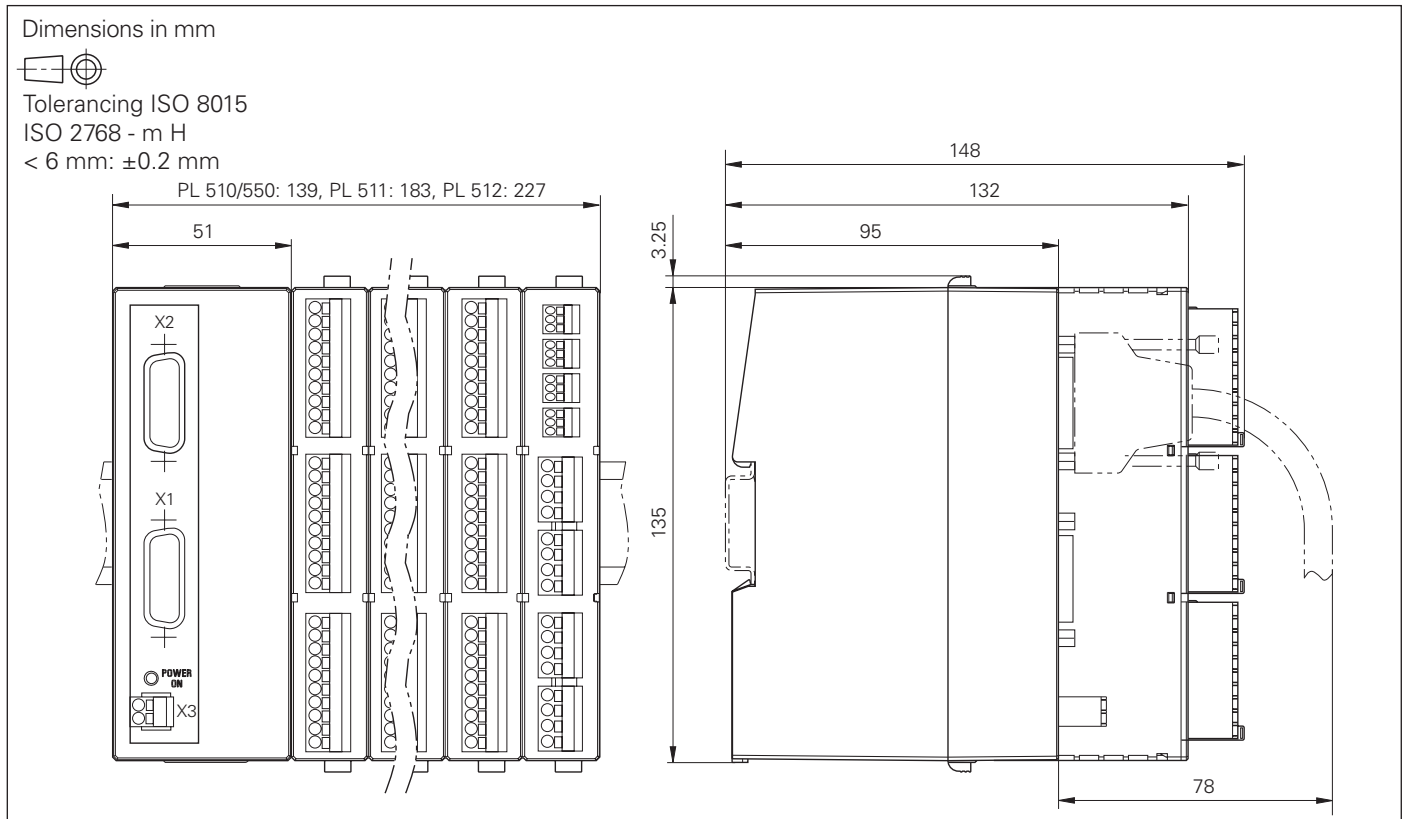
HR 410



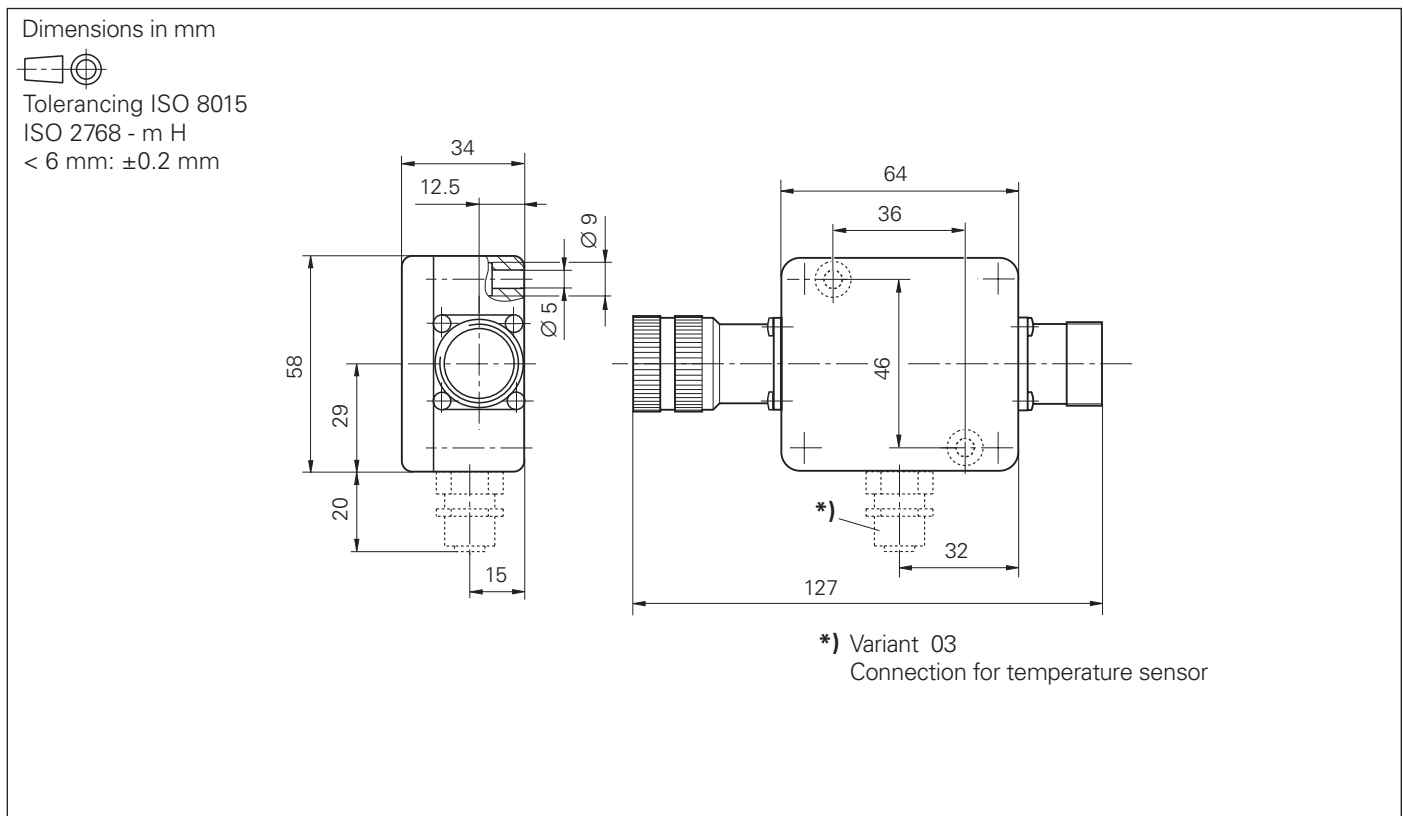
Adapter Cable for HR 410



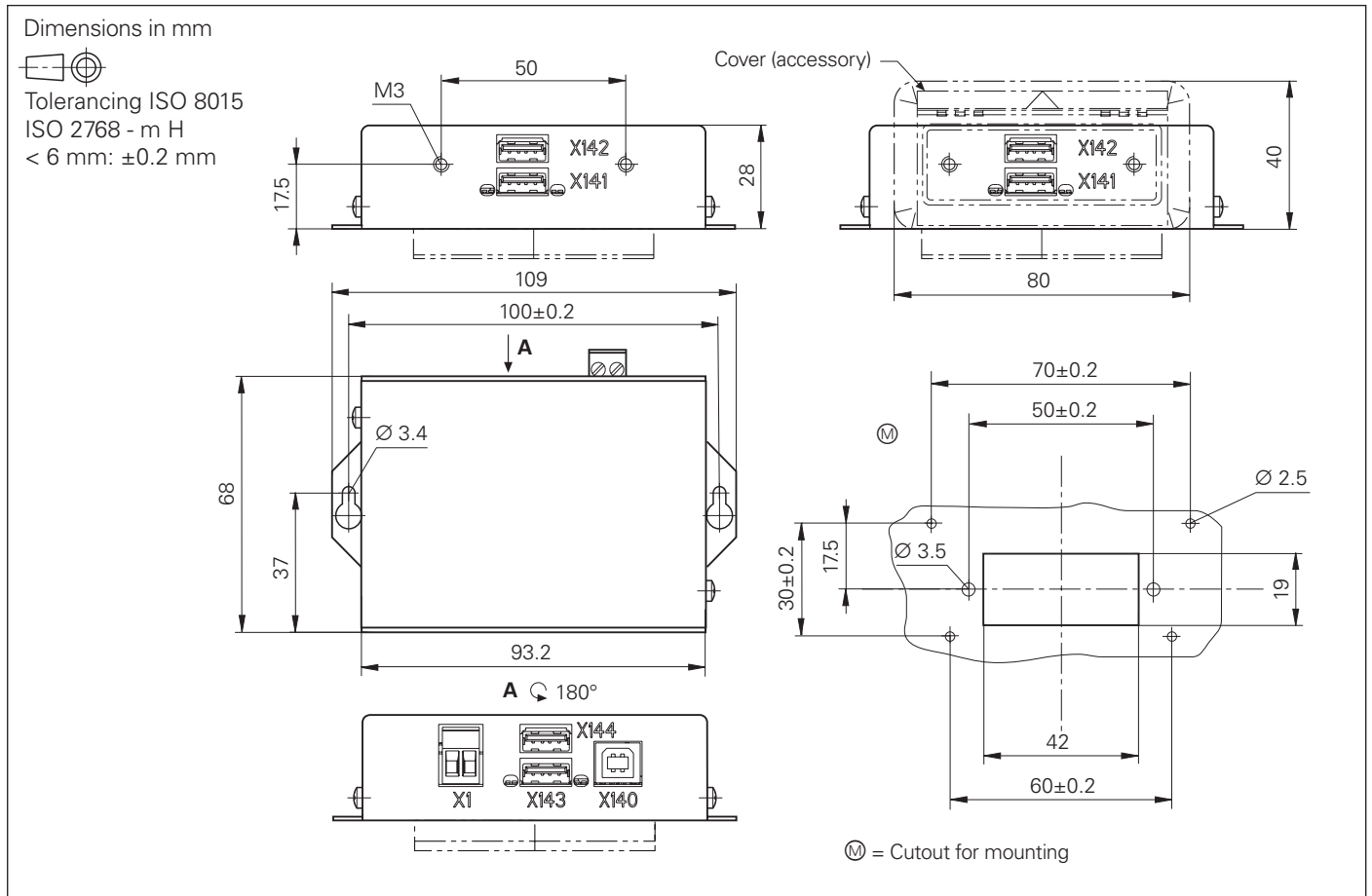
PL 510



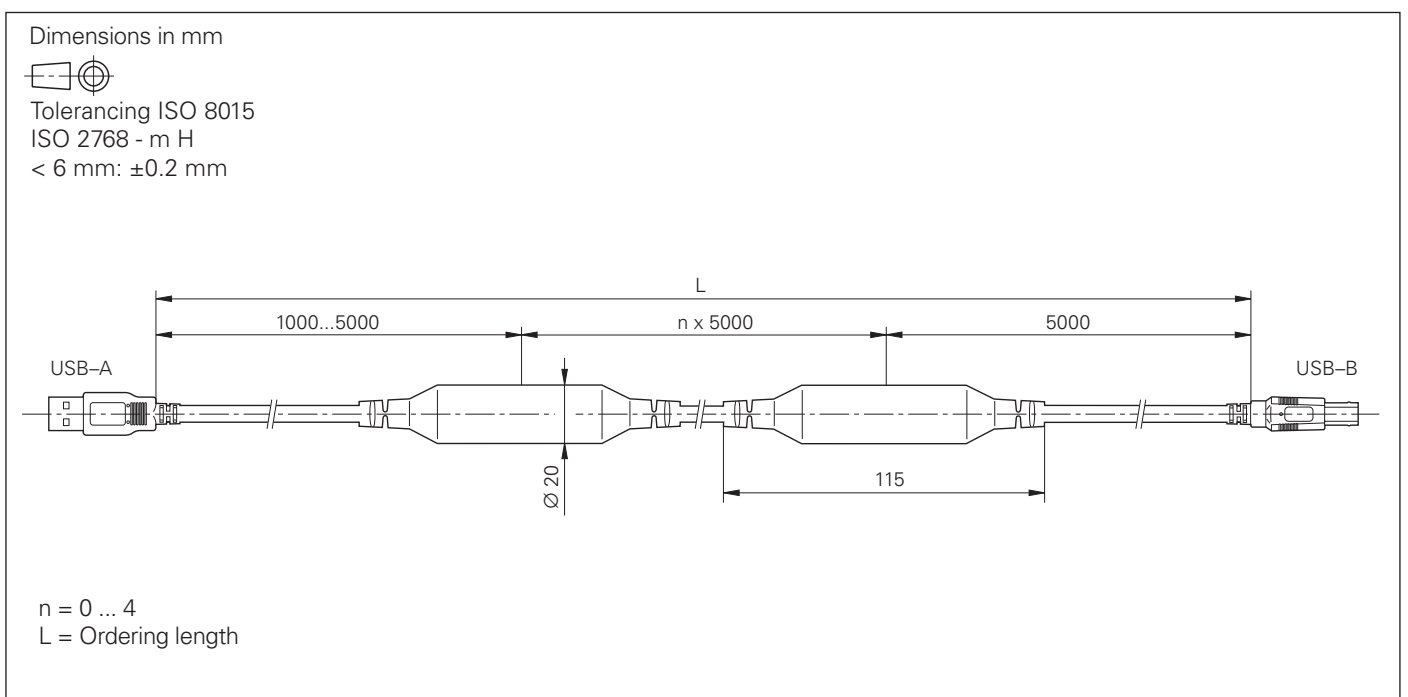
Line Drop Compensator for EnDat Interface



USB Hub



USB Extension Cable with Hubs



Documentation

The following are supplied with a control system:

- 1 MANUALplus 620 User's Manual
- 1 MANUALplus 620 Pilot (brief programming guide; in preparation)

This documentation must be ordered separately in the language required.

Further documentation is available from HEIDENHAIN.

Technical documentation

- HEIDENHAIN Technical Manual for **MANUALplus 620** in English or German ID 634863-xx
- Technical Manual **for Inverter Systems and Motors** ID 208962-xx

The Technical Manuals are in loose-leaf format in a ring binder. Supplementary issues with update information and replacement sheets are sent when the software or hardware is updated.

User documentation

- **MANUALplus 620** User's Manual ID 634864-xx

Other documentation

- **Motors** brochure ID 208893-xx
- **MANUALplus 620** brochure ID 634865-xx
- **DataPilot MP 620** CD-ROM In preparation
- **Inverter Systems** brochure ID 622420-xx

HEIDENHAIN Service

Technical support HEIDENHAIN offers the machine manufacturer technical support to optimize the adaptation of the MANUALplus to the machine—including on site.

Replacement control system In the event of a fault, HEIDENHAIN guarantees the rapid supply of a replacement control system (usually within 24 hours in Europe).

Hotline Our service engineers are naturally at your disposal by telephone if you have any questions on the interfacing of the control or in the event of faults.

TNC support	☎ +49 (8669) 31-3101 E-mail: service.nc-support@heidenhain.de
PLC programming	☎ +49 (8669) 31-3102 E-mail: service.plc@heidenhain.de
NC programming	☎ +49 (8669) 31-3103 E-mail: service.nc-pgm@heidenhain.de
Measuring systems	☎ +49 (8669) 31-3104 E-mail: service.ms-support@heidenhain.de
Lathe controls	☎ +49 (8669) 31-3105 E-mail: service.lathe-support@heidenhain.de

Seminars

HEIDENHAIN provides technical customer training in the following subjects:

- NC programming
- PLC programming
- MANUALplus 620 mounting and commissioning
- MANUALplus 620 service
- Encoder service
- Special training for specific customers

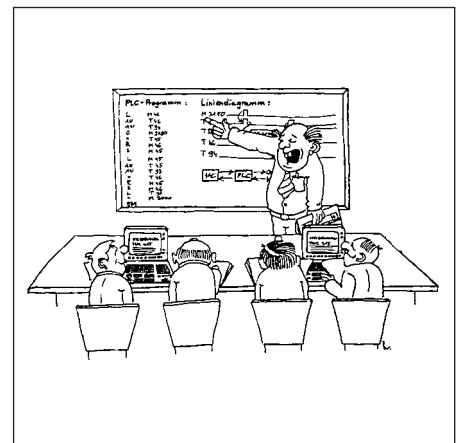
For more information on dates, registration, etc. call in Germany:

☎ +49 (8669) 31-2293 or 31-1695

FAX +49 (8669) 31-1999

E-mail: mtt@heidenhain.de

www.heidenhain.de

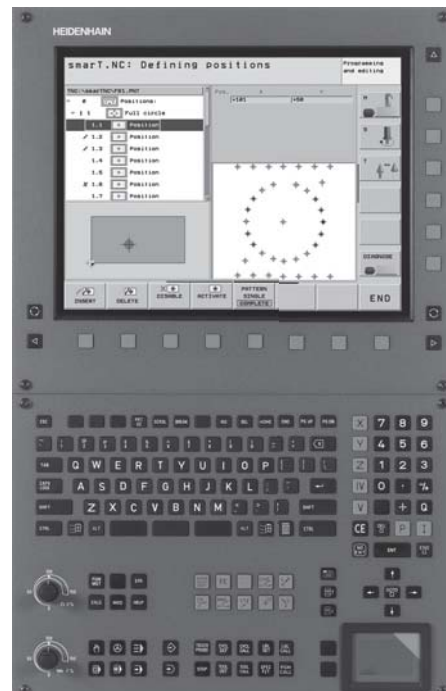


Other HEIDENHAIN Controls

iTNC 530 contouring control

Information:
brochure
iTNC 530

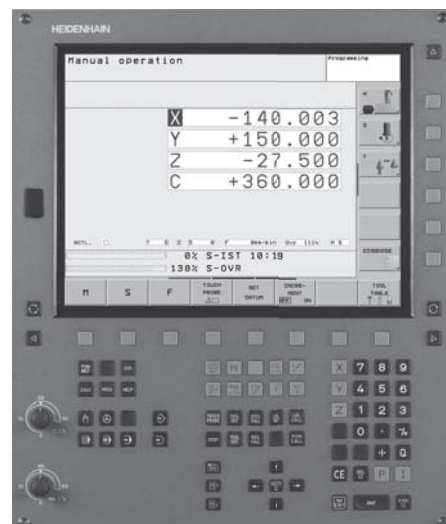
- Contouring control **for milling, drilling and boring machines, and machining centers**
- Max. 11 closed-loop **axes** and servo-controlled spindle
- For **digital drive control** with HEIDENHAIN inverter systems
- Flat-panel color display (15-inch)
- Keyboard unit with alphanumeric keys
- Program memory on integrated hard disk
- Program input with smarT.NC in HEIDENHAIN conversational format or according to ISO
- DXF file import
- External programming on CAD/CAM systems or programming stations
- FK free contour programming
- **User aids:** Programming graphics, verification graphics, program-run graphics
- **Programming aids:** Milling, drilling and boring cycles, parametric programming, coordinate transformation, subprogramming
- Five-axis machining with TCPM and 3-D tool compensation
- Tilted working plane with PLANE function and machining with a rotary table
- HSC machining
- Collision monitoring (optional)
- Tool, datum, preset and pallet tables
- Connection of HR electronic handwheels, TS workpiece touch probes and TT tool touch probes
- Data interfaces: Ethernet 100BaseT; RS-232-C /V.24; RS-422 /V.11; USB 1.1



TNC 320 contouring control

Information:
brochure
TNC 320

- Compact contouring control for **milling, drilling and boring machines**
- Three (optionally four) closed-loop **axes** plus one closed-loop spindle
- Analog speed command interface
- Integrated keyboard and flat-panel color display (15-inch)
- Program memory: 10 MB on Compact Flash memory card (CFR)
- Program input in HEIDENHAIN conversational language, execution of DIN/ISO programs
- FK free contour programming
- Subprogramming and fixed cycles
- **User aids:** Programming graphics, verification graphics, program-run graphics
- **Programming aids:** Milling, drilling and boring cycles, parametric programming, coordinate transformation, subprogramming
- Machining with rotary tables (option)
- Tool and reference-point tables
- Connection for one HR electronic handwheel and one TS workpiece touch probe
- Interfaces: Ethernet 100BaseT, RS-232-C/V.24, USB 1.1



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