Rexroth
Bosch Group

Digital control electronics

RE 30543/2018-09 1/16
Replaces: 12.10

Type VT-HACD-3

H7688

Component series 2X

Table of contents

Features

- Use as **control electronics** for control loops with PIDT1 controller and optional state feedback
- Substitutional closed-loop control (e.g. position control with superimposed pressure/force control) possible
- Use as **command value electronics** for generating, linking and standardizing signals
- Input for digital position measurement systems (2 x SSI or 1 x incremental)
- 6 analog inputs, voltage (±10 V, 0...10 V) and current (4...20 mA) switchable via software, input resistance of AI1 > 10 MΩ
- 3 analog outputs, 1x switchable voltage (±10 V, 0...10 V) or current (0...20 mA, 4...20 mA), 2x voltage (±10 V)
- Various possible signal linking and switch-over options
- Enable input and OK output
- 8 digital inputs
- 7 digital outputs, configurable
- Parameterizable ramp function
- 32 blocks with command values, velocities and controller parameters
- Adjustment to hydraulic drive by means of area adjustment, characteristic curve correction, overlap compensation, residual velocity logic and zero point correction
- +10 V reference voltage output
- Serial interface RS232
- Up to 32 electronics can be interconnected for parameterization and diagnosis via the local bus

Areas of application

- Machine tools
- Plastics processing machines
- Special machinery
- Presses
- Transfer systems

Technology functions

- Sequence parameterization
- Positioning
- Pressure control
- Force control
- Tables

Hydraulic axes

- Measurement system:
  - incremental or absolute (SSI, gray, binary)
  - analog 0 to ±10 V and 0(4) to 20 mA
- Actuating variable output voltage or current
- Freely configurable controller variants
  - Position/pressure/force/velocity controller
  - substitutional closed-loop control (position/pressure)

Programming

- User programming with PC

Operation

- Comfortable management of the machine and measured data on the PC

Process connection

- Digital inputs and outputs,
- Analog inputs and outputs,
- PROFIBUS DP for the communication with a superior control system
- EtherNet/IP
- PROFINET RT

Assembly

- Top hat rail 35 mm

CE conformity

- EMC Directive 2004/108/EC
  Applied harmonized standards:
  EN 61000-6-2:2005
  EN 61000-6-3:2007

Further information

www.boschrexroth.com/hacd

Ordering code

VT-HACD – 3 – 2X / 0 / I – 00 – 000

Digital control electronics		
Standard	**= 3**	
Component series 20 to 29 (20 to 29: unchanged technical data and pin assignment)	**= 2X**	
Bus system		
without bus	**0 =**	
PROFIBUS DP	**P =**	
Ethernet-based:		
PROFINET RT	**N =**	
EtherNet/IP	**E =**	
Position transducer		
Incremental/SSI	**I =**	
Hardware marking		
Options		

Included in the scope of delivery:

Mating connector for

- Port X1S (Phoenix Mini Combicon, 3-pole)
- Port X2A1 (Weidmüller B2L 3.5/18 LH SN SW)
- Port X2M1 (Weidmüller B2L 3.5/30 LH SN SW)

Recommended accessories (can be ordered separately)

Denomination	Material number
Interface cable RS232, length 3 m	**R900776897**
USB RS232 converter	**R901066684**
Connector type 6ES7972-0BA41-0XA0 for PROFIBUS DP	**R900050152**
CD with BODAC software SYS-HACD-BODAC-01/	**R900777335**

Spare part kit (can be ordered separately)

Denomination	Material number
STECKERSATZ VT-HACD-3-2X...*ET	**R961009670**

Software project planning

Project planning

The creation of a parameter file forms the basis for the function of the HACD. The parameter file contains the block structure of the HACD in which the links of the variables will be created. The parameter files are created in BODAC. The parameter file can be created offline and transferred to the HACD by means of a PC.

Proceed as follows for this software project planning:

1. Selection of the HACD.
2. Application is defined by means of the block structure.
3. Setting of the parameter values (sensor technology, controllers...).
4. The data is sent to the HACD.
5. Storage of the data in the flash.
6. The setting and the machine sequence are optimized at the machine.

PC program BODAC

To implement the project planning tasks, the BODAC PC program is available to the user. It can be used for the programming, setting and diagnosis of the HACD.

Scope of services:

– Convenient dialog functions for the online or offline setting of the machine data
– Dialog window for the online setting of the parameter values
– Comprehensive options for displaying process variables, digital inputs, outputs, and flags
– Recording and graphical representation of up to eight process variables with great selection of trigger options

PC system requirements:

– Windows XP, Windows Vista, Windows 7, Windows 10
– RAM (recommendation: 256 MB)
– 250 MB of available hard disk capacity

Notice:

The BODAC PC program is **not** included in the scope of delivery. It is available for free download!

Download on the Internet: www.boschrexroth.com/hacd

Enquiries: support.hacd@boschrexroth.de

Overview of the controller functions

Position controller:
- PDT1 controller
- Linear amplification characteristic curve
- Direction-dependent gain adjustment
- Gain modification via the program possible
- Valve characteristic curve adaptation
- Fine positioning
- Residual voltage principle
- Compensation of zero point errors
- State feedback via
  - Pressure,
  - Pressure differential
  - Position
- Command value feedforward

Pressure / force controller:
- PIDT1 controller
- I share switchable via window
- Pressure differential evaluation
- Command value feedforward

Velocity controller:
- PI controller
- I share switchable via window

Monitoring functions:
- Dynamic following error monitoring
- Cable break monitoring for incremental and SSI encoder
- Cable break monitoring for sensors
- Cable break monitoring for analog signals

Functional description

The VT-HACD-3-2X control electronics is a module for top hat rail mounting.

A microcontroller controls the entire process, makes adjustments, establishes connections and realizes the closed control loops. Data for configuration, command values and parameters are stored in a FLASH in a non-volatile form.

The BODAC PC program is used for the entire configuration and also for the parameterization and diagnosis. Besides the switches for address setting, the module is not equipped with any additional hardware switches. For the configuration, the HACD has to be connected to a PC via a serial interface (RS 232, 1:1 cable).

The configuration and thus the creation of applications are very simple - simply connect the pre-defined functional components. For this purpose, no programming knowledge is necessary.

A mode is available:

- **Structural editor**
  Own motion sequences can be established. For this purpose, 32 blocks are available.
  Each block contains: Command value, ramp times, (velocity ±, acceleration ±) and controller parameters.

  Blocks are activated by setting trigger conditions: Setting digital inputs, comparing signals with freely definable thresholds or expiry of waiting times.

Signal linking [6] [8] [17]

The HACD has various signal linking options both for the input and the output side, whereas 2 signals each can be linked. These are functions such as addition, subtraction, multiplication, division as well as minimum/ maximum value generator, area ration and limiter:

+ = Addition: Z = X + Y

– = Subtraction: Z = X – Y

* = Multiplication: Z = X * Y / 100

/ = Division: Z = X / Y * 100

MIN = Minimum value generator: Z = MIN (X, Y)

MAX = Maximum value generator: Z = MAX (X, Y)

RATIO = Ratio input:
for RATIO >1: Z = X * RATIO – Y
for RATIO <1: Z = X – Y / RATIO
(e.g. area ratio for pressure differential measurement)

LIMIT = Signal limiter: Z = MIN (|X|, |Y|) * sign (X)

JUMP = Jump generator: Z = MAX (|X|, |Y|) * sign (X)

with Z ... result
X ... 1st signal
Y ... 2nd signal

T1 Lag = Low pass filter

Analog I/O [1] [15]

The 6 analog inputs are switchable between ±10 V, 0...10 V, 0...20 mA by means of the software.

For the analog output AO1, you can switch between ±10 V, 0...10 V, 0...20 mA and 4...20 mA by means of the software.

AO2 and AO3 are fixedly set to ±10V.

The output is switched over so that the whole range of the analog-digital converter is used.

Both working range and error detection can be defined for all analog inputs.

The analog outputs can be adjusted by means of amplification and offset.

Digital I/O [3] [16]

The HACD has 9 digital inputs and 8 digital outputs.

An input has the fix functionality Enable, a digital output the fixed functionality OK.

Further digital inputs are used for the triggering of blocks (see blocks and triggering).

The function of each digital output can be determined by the selection from a predefined list:

- Command value = actual value
- Actual value higher or lower than the adjustable threshold
- Waiting time completed
- Ramp active
- internal flag set
- Error flag set
- Table completed
- Error status
- Block timeout
- Controller active
- Absolute value (actual value) < window
- Absolute value (command value) < window
- Incremental home position

[ ] = Assignment to the block diagram on page 8/9

Functional description (continued)

Digital position measurement system

If VT-HACD-3-2X is used as control electronics, digital position measurement systems of type SSI or incremental can be used for actual value recording.

Limitations of use for the incremental encoder

The maximum frequency of the incremental encoder input (f_G) of the HACD is 250 kHz. The maximum travel velocity of the drive, the resolution (res) of the encoder system used and the possible signal evaluation by EXE (interpolation and digitalizing electronics) determine the frequency.

Determination formulas

Encoder resolution at given maximum velocity:

$$\text{Res}\,[\mu\text{m}] \geq \frac{v\left[\frac{\text{m}}{\text{s}}\right] \times 10^3}{f_G\,[\text{kHz}] \times \text{EXE}}$$

Velocity at specified encoder resolution:

$$v\left[\frac{\text{m}}{\text{s}}\right] \leq \frac{\text{Res}\,[\mu\text{m}] \times \text{EXE} \times f_G\,[\text{kHz}]}{10^3}$$

Controller

If the HACD is used as control electronics, select "Controller" for signal linking [8].

The LCx signals indicate the command value branch, the LFBx signals indicate the actual value branch. [8]

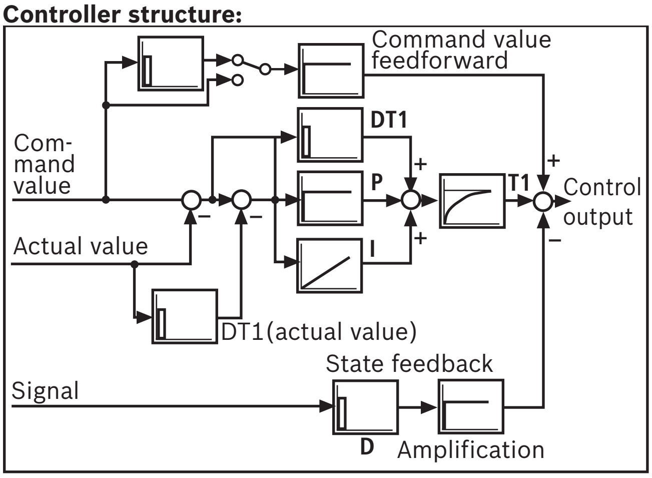
Both SSI encoder or incremental encoder [2] (digital measurement system) and one or more analog sensors can be used as actual value signal.

The controller structure is designed as PIDT1 controller, whereas each share can be activated or deactivated individually. Thus, also a P or PT1 controller can be implemented for example. The I share can additionally be controlled via a window (upper and lower limit).

Control parameters can be set in blocks or independently of blocks.

A state feedback can be used for controller output damping.

Controller structure:



Adjustment to hydraulic system

For the optimum adjustment to the particularities of hydraulic drives, the following functions are implemented upstream of the analog output:

- Direction-dependent amplification [10]

  For positive and negative values, the amplification can be set separately. In this way, adjustment to the area ratio of a differential cylinder is possible.
- Characteristic curve correction [11]

  In this way, the progressive flow characteristics of proportional directional valves are compensated or an inflected characteristic curve is realized.
- Overlap jump/residual velocity [12]

  When using valves with positive overlap, a fine positioning can be used in case of a PDT1 controller in order to increase the static accuracy. This fine positioning can be selected according to the residual voltage principle and as overlap jump.
- Zero point correction (offset) [13]

  Serves the correction of the zero point of the connected proportional servo valve.

Error detection and treatment

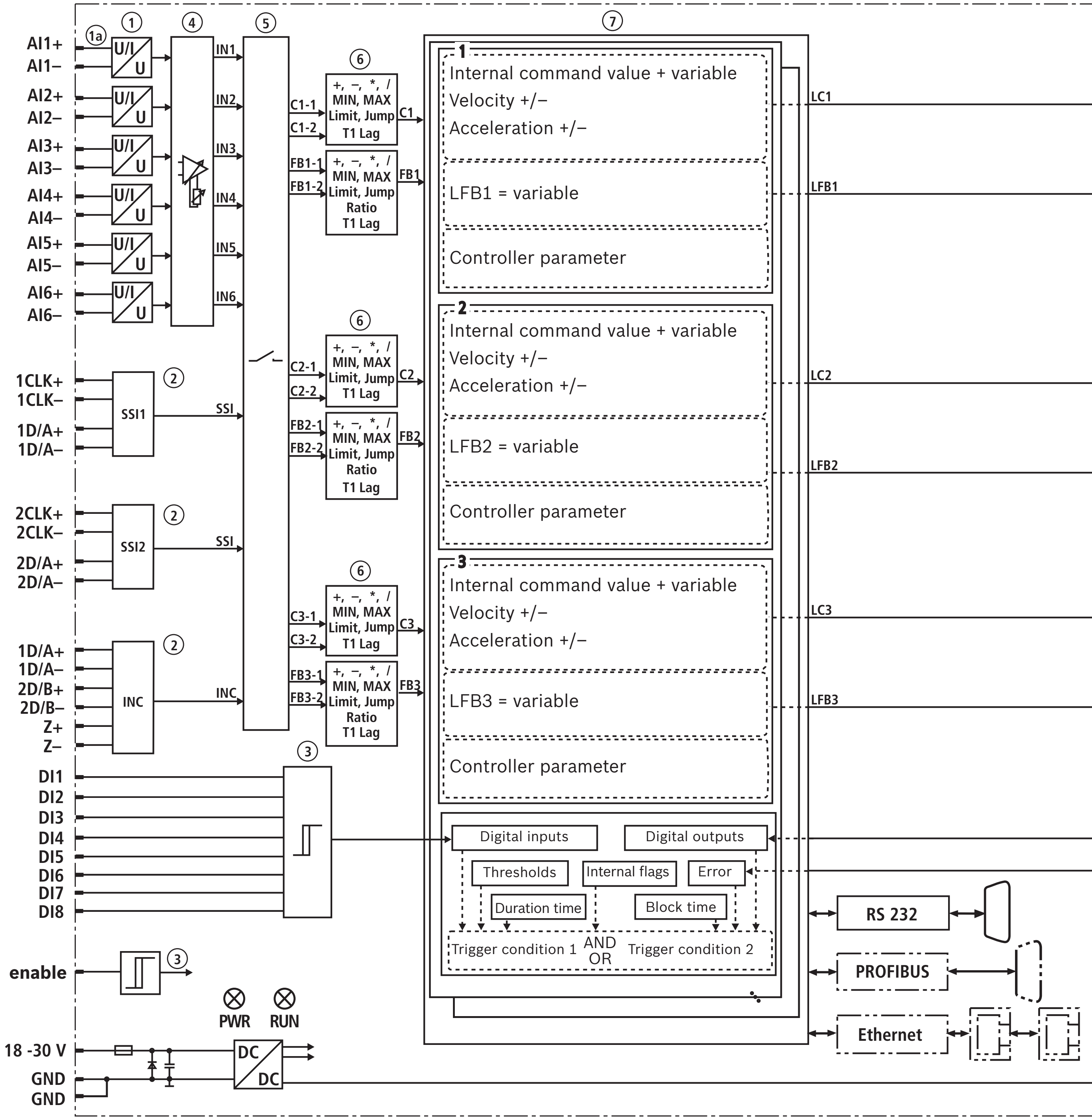
The HACD supports numerous error monitoring possibilities:

- Monitoring of analog inputs for lower deviation or exceedance of the range
- Monitoring the sensor technology for cable break
- Control error monitoring when configuring the HACD as controller
- Monitoring of the supply voltage, all internal voltages as well as the +10V reference voltage
- Monitoring the microcontroller (watchdog) as well as the memory (checksum)

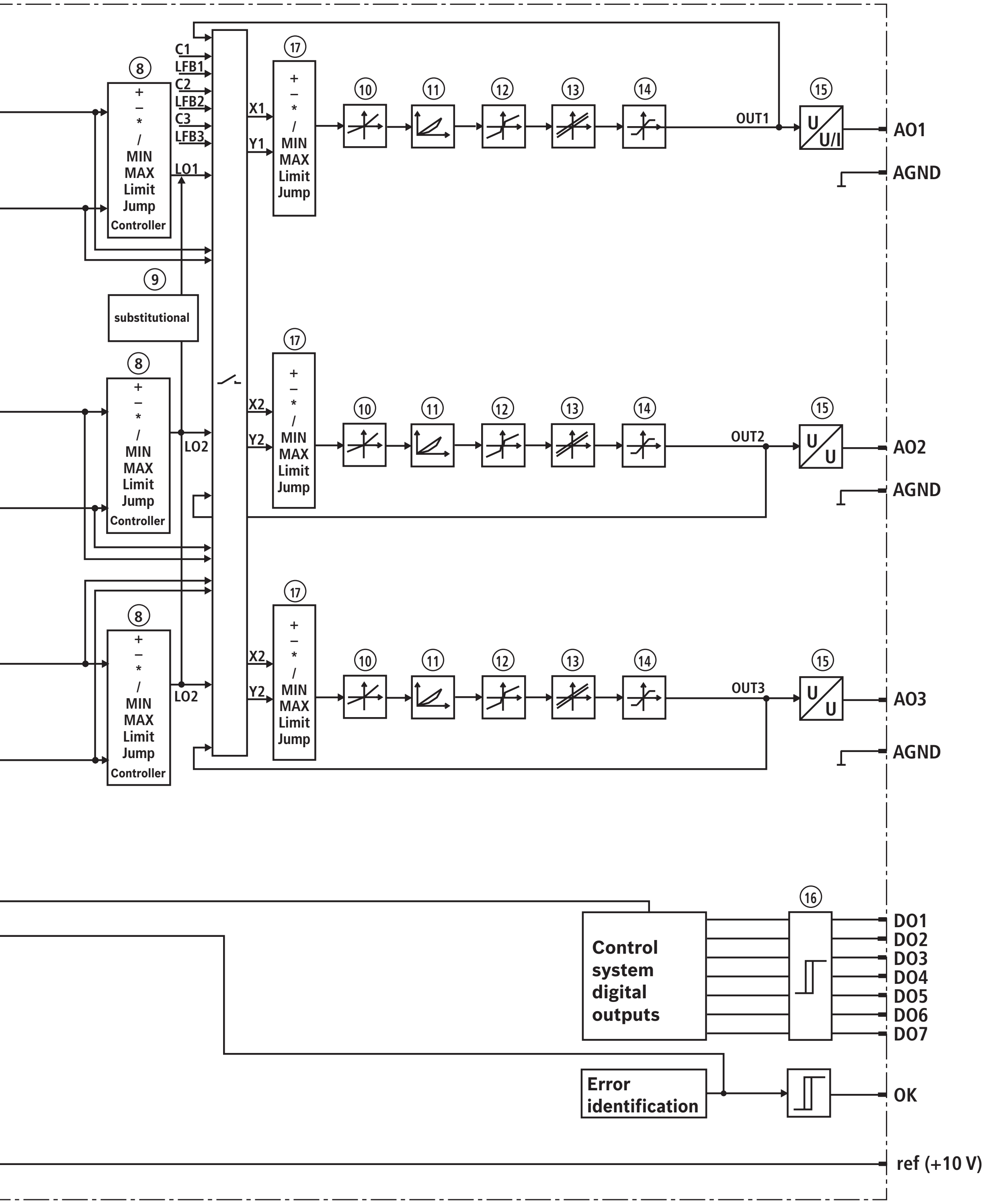
The error monitoring as well as its reaction can be configured as well.

[ ] = Assignment to the block diagram on page 8/9

Block diagram: Structural editor



1 Analog voltage or current inputs
1a High-impedance input AI1
2 SSI or incremental
3 Enable input and digital inputs
4 Analog input adjustment
5 Switching matrix
6 Math. connection of inputs
7 32 blocks for command value generation, controller parameter switching
8 Math. connection and/or controller
9 Substitutional control
10 Direction-dependent gain
11 Characteristic curve adjustment
12 Residual velocity and overlap jump

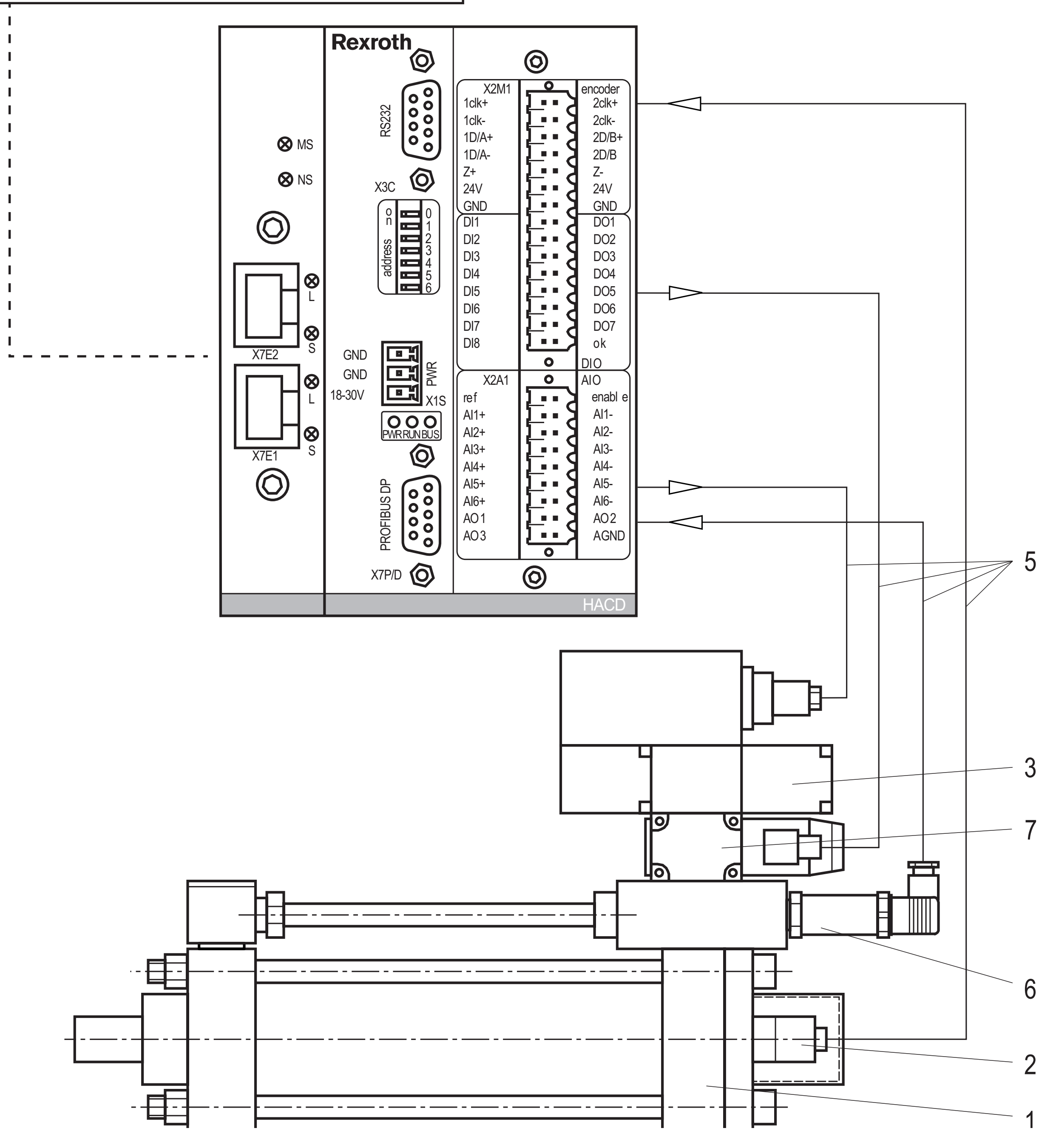


13 Offset
14 Limitation
15 Analog voltage or current outputs
16 OK output and digital outputs
17 Math. connection of outputs

System overview, interfaces

Superior control system
Possible interfaces with the VT-HACD-3-2X:
– analog signals
– digital inputs/outputs
– serial interface
– Bus systems

Example:
VT-HACD-3-2X/... with one hydraulic cylinder axis



1 Differential cylinder
2 integrated position measurement system
3 Proportional servo valve with integrated control electronics
4 VT-HACD-3-2X
5 Connection cable
6 Pressure transducer
7 Sandwich plate shut-off valve (with connector switching amplifier)

Technical data

Operating voltage [1]	U_B	18 to 30 VDC
Current consumption at 24VDC		200 mA (also observe power for connected sensors/ actuators)
Processor		32 bit power PC
Analog inputs (AI)	Quantity	6
– Voltage inputs (differential inputs)		
• Channel number		max. 6 (selectable via software)
• Input voltage	U_E	max. +15 V to −15 V (+10 V to −10 V measurable)
• Input resistance	R_E	> 10 MΩ (AI1) 200 kΩ ± 5% (AI2 to AI6)
• Resolution		5 mV
• Non-linearity		±0.25%
• Calibration tolerance		max. 40 mV (with factory settings)
– Current inputs		
• Channel number		max. 6 (selectable via software)
• Input current	I_E	0...20 mA
• Leakage current	I_V	0.1 to 0.4%
• Resolution		5 μA
Analog outputs	Quantity	3
AO1 configuration as voltage output		
Output voltage	U	0...10 V or ±10 V (configurable)
Output current	I_{max}	10 mA
Load	R_{Lmin}	1 kΩ
Resolution		1.25 mV (14 bit)
Residual ripple		±15 mV (without noise)
AO1 configuration as current output		
Output current	I	0...20 mA or 4...20 mA (configurable)
Load	R_{max}	500 Ω
Resolution		1.25 μA
Residual ripple		±15 μA (without noise)
AO2 / AO3		
Output voltage	U	±10 V
Output current	I_{max}	10 mA
Load	R_{min}	1 kΩ
Resolution		1.25 mV (14 bit)
Residual ripple		±25 mV (without noise)

[1] If a 24V encoder supply is realized directly via the VT-HACD-3-2X (supply voltage is looped in), the encoder specification has to be observed.

Technical data, continued

X3C, interface for BODAC X7P, interface for bus X7E1(2), interface for Ethernet		RS232 PROFIBUS DP (max. 12 MBaud acc. to IEC 61158) PROFINET RT, EtherNet/IP
Switching inputs (DI) and/or outputs (DO)	Quantity	DI = 9 / D0 = 8
Switching inputs (DI)	Logic level	log 0 (low) ≤ 5 V; log 1 (high) ≥ 10 V to U_B, I_e = 7 mA with U_B = 24 V
	Port	Flexible conductor up to 1.5 mm^2
Switching outputs (DO)	Logic level	log 0 (low) ≤ 2 V; log 1 (high) ≤ U_B; I_{max} = 20 mA, maximum load capacity C = 0.047 μF
	Port	Flexible conductor up to 1.5 mm^2
Reference potential for all signals		GND
Digital position transducer (encoder)		
– Incremental transducer (transducer with TTL output)		
• Input voltage	log 0	0 to 1 V
	log 1	2.8 to 5.5 V
• Input current	log 0	–0.8 mA (with 0 V)
	log 1	0.8 mA (with 5 V)
• Max. frequency referring to Ua1	f_{max}	250 kHz
– SSI transducer (Due to the higher control quality, an SSI transducer with clock synchronization should be used.)		
• Coding		Gray code / binary code
• Data width		adjustable up to max. 28bit
• Line receiver / line driver		RS485
– Voltage supply for SSI transducers via VT-HACD-3-2X	*U, I*	U_B, **max. 200 mA**
Reference potential for all signals		GND
Reference voltage per axis electronics	U_{ref}	+10 V ± 25 mV (20 mA)
Dimensions		see page 14
Assembly		Top hat rail TH 35-7.5 or TH 35-15 according to EN 60715
Admissible operating temperature range	ϑ	0 to 50 °C
Storage temperature range	ϑ	–20 to +70 °C
Protection class according to EN 60529:1991		IP 20
Weight		
without Ethernet	*m*	930 g
with Ethernet	*m*	1162 g
CE conformity		see page 2

Further technical details upon request.

Notice:
For information on the **environment simulation testing** for the areas EMC (electro-magnetic compatibility), climate and mechanical load, see data sheet 30543-U.

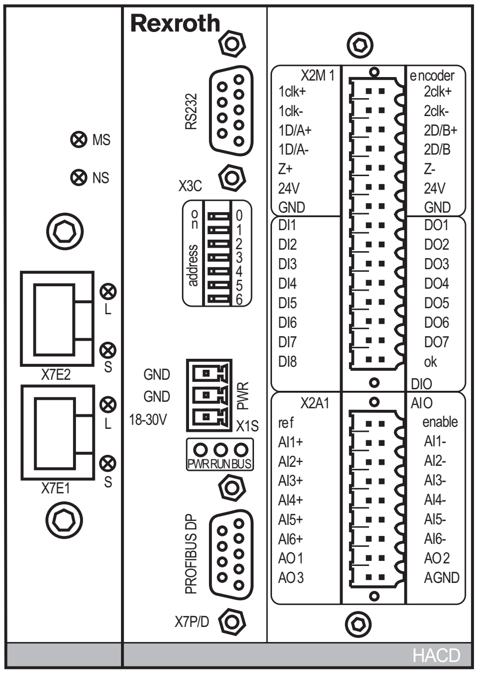
Pin assignment

X3C	RS232
Pin	
1	LCAN_H
2	TxD
3	RxD
4	reserved
5	GND
6	reserved
7	reserved
8	reserved
9	LCAN_L

X1S	Power
Pin	
1	GND
2	GND
3	18 – 30 V

X7P PROFIBUS DP	
Pin	
1	reserved
2	reserved
3	RxD/TxD-P
4	CNTR-P
5	DGND
6	VP
7	reserved
8	RxD/TxD-N
9	reserved

X7E1, X7E2
Ethernet ports



X2M1	Encoder/DIO (Digital)
1clk+	2clk+
1clk–	2clk–
1D/A+	2D/B+
1D/A–	2D/B–
Z+	Z–
24V	24V
GND	GND
DI1	DO1
DI2	DO2
DI3	DO3
DI4	DO4
DI5	DO5
DI6	DO6
DI7	DO7
DI8	OK

X2A1	AIO (Analog)
ref	enable
AI1+	AI1–
AI2+	AI2–
AI3+	AI3–
AI4+	AI4–
AI5+	AI5–
AI6+	AI6–
AO1	AO2
AO3	AGND

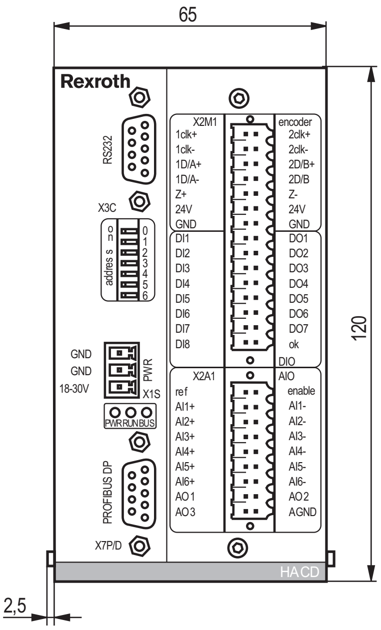
Notes:

– The pins marked with **"reserved"** are reserved and must not be connected!

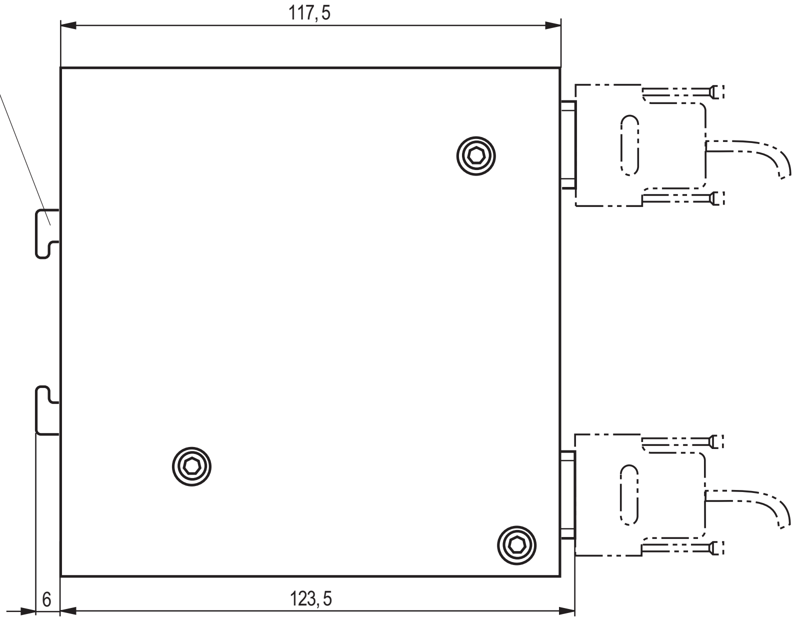
– PROFIBUS DP (port X7P/D) is not available with the Ethernet version.

Unit dimensions (dimensions in mm)

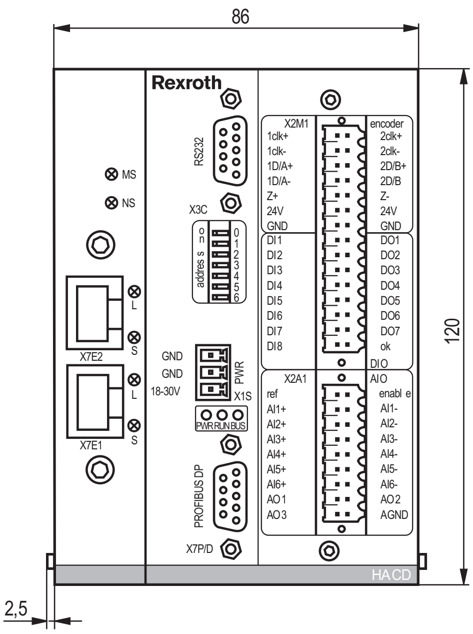
VT-HACD-3-2X/
(**without** Ethernet)



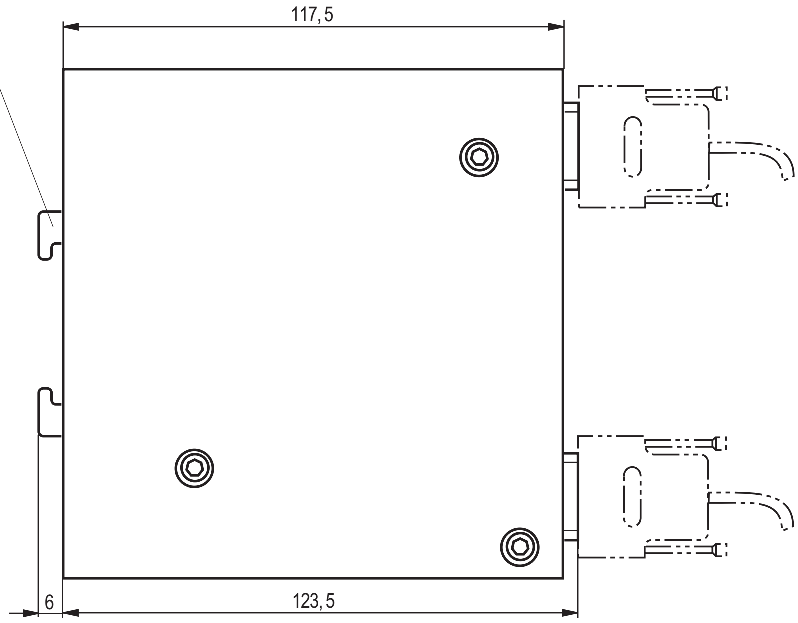
Assembly on top hat rail TH 35-7.5 or TH 35-15 according to EN 60715



VT-HACD-3-2X/
(**with** Ethernet)



Assembly on top hat rail TH 35-7.5 or TH 35-15 according to EN 60715



Project planning / maintenance instructions / additional information

Product documentation for VT-HACD-3-2X

- **Data sheet 30543**
- **Operating instructions 30543-B**
- **Environmental compatibility statement 30543-U**
- **BODAC software description 30543-01-B**
- **Commissioning instructions PROFIBUS interface 30543-01-Z**
- **Commissioning instructions EtherNET/IP interface 30543-04-Z**
- **Commissioning instructions PROFINET RT interface 30543-05-Z**
- **General information on the maintenance and commissioning of hydraulic components 07800/07900**

Commissioning software and documentation on the Internet: www.boschrexroth.com/HACD

Maintenance instructions:

– The devices have been tested in the plant and are supplied with default settings.
– Only complete devices can be repaired. Repaired devices are returned with default settings. User-specific settings are not accepted. The machine end-user must transfer all appropriate user parameters and programs again.

Notes:

– Electrical signals provided via control electronics (e.g. "No error" signal) must not be used for switching safety-relevant machine functions! (See also the European standard "Safety requirements for fluid power systems and their components - Hydraulics", EN 982.)
– If electro-magnetic interference is to be anticipated, suitable measures must be taken to ensure the function (depending on the application, e.g. shielding, filtration)!
– For additional information, see BODAC software description 30543-01-B and operating instructions 30543-B
– The upper and lower ventilation slots must not be concealed by adjacent devices in order to provide for sufficient cooling.