Rexroth
Bosch Group

Digital closed-loop control electronics

RE 30543/12.10 1/16
Replaces: 01.10

Type VT-HACD-3

CE

H7688

Component series 2X

Table of contents

Features

- Use as **closed-loop control electronics** for closed 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) selectable via software, input resistance of AI1 > 10 MΩ
- 3 analog outputs, 1x selectable voltage (±10 V, 0…10 V) or current (0…20 mA, 4…20 mA), 2x voltage (±10 V)
- Numerous possibilities of signal linking and switch-over
- Release 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

Fields of application

- Machine tools
- Plastics processing machines
- Special machines
- 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 using a PC

Operation

- Comfortable administration of the machine and measuring data on a PC

Process connection

- Digital inputs and outputs,
- Analog inputs and outputs,
- PROFIBUS DP to communicate with a superior control
- EtherNet/IP
- PROFINET RT

Installation

- Top hat rail 35 mm

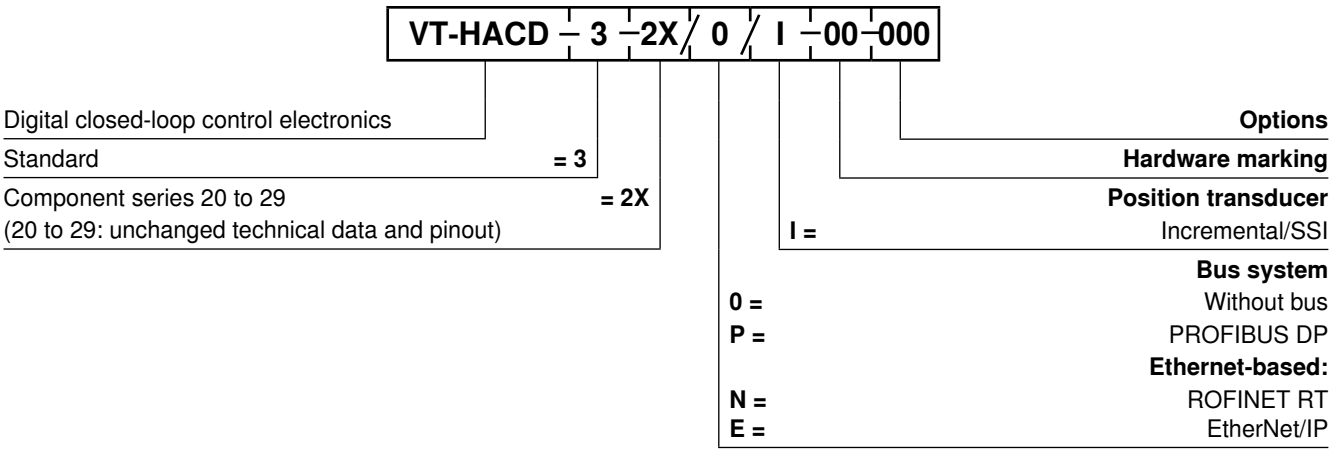
CE conformity

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

More information

www.boschrexroth.com/hacd

Ordering code



Included within 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)

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

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.

This software project planning is implemented according to the following steps:

1. Selection of the HACD.
2. Application is defined by means of the block structure.
3. Setting of the parameter values (sensors, 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

For the implementation of the project planning tasks, the BODAC PC program is available to the user. It serves the programming, setting, and diagnosis of the HACD.

Scope of services:

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

PC-System requirements:

- Windows XP, Windows Vista, Windows 7
- Random access memory (256 MB recommended)
- 250 MB free hard disk capacity

Note:

The BODAC PC program is **not** included in the scope of delivery. It can be downloaded in the Internet free of charge!

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

Inquiries: support.hacd@boschrexroth.de

Overview of the controller functions

Position controller:

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

Pressure/force controller:

- PIDT1 controller
- I component switchable via window
- Pressure differential analysis
- Command value provision

Velocity controller:

- PI controller
- I component switchable via window

Monitoring functions:

- Dynamic tracking 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 closed-loop control electronics is a module that is installed on a top hat rail.

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

The entire configuration and the parameterization and diagnosis are carried out via the BODAC PC program. Apart from the switches for the address setting, the module does not contain any other 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 - you just have to link pre-defined functional components. For this purpose, no programming knowledge is necessary.

One mode is available:

- **Structural editor**
  Own motion sequences can be created. 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 periods.

Signal links [6] [8] [17]

The HACD offers numerous possibilities for linking signals on the input and on the output side, whereas it is in each case possible to link 2 signals. This includes functions like addition, subtraction, multiplication, division as well as minimum/maximum value generator, area ratio 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 = Entry of a ratio:
for RATIO >1: Z = X * RATIO – Y
for RATIO <1: Z = X – Y / RATIO
(e.g. area ratio with 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
X … 2nd signal

T1 Lag = Low-pass filter

Analog I/O [1] [15]

For the 6 analog inputs, you can switch 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 ±10 V.

The switching is performed by utilizing the whole range of the analog-digital converter.

For all analog inputs, working range and error detection can be defined.

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 Release, a digital output the fixed functionality OK.

The other digital inputs are used for triggering blocks (see blocks and triggering).

The function of each digital output can be determined by means of selection from a pre-defined list:

- Command value = Actual value
- Actual value larger or smaller than an adjustable threshold
- Waiting period expired
- Ramp active
- Internal flag set
- Error flag set
- Table ended
- 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

When using the VT-HACD-3-2X as closed-loop control electronics, digital position measurement systems of type SSI or incremental can be used for recording the actual value.

Limitations of use 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 analysis by an EXE (interpolation and digitalization electronics) determine the frequency.

Determination formulae

Encoder resolution with given maximum velocity:

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

Velocity with given encoder resolution:

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

Controller

If the HACD is used as closed-loop control electronics, the “Controller” entry has to be selected in the signal linking [8].

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

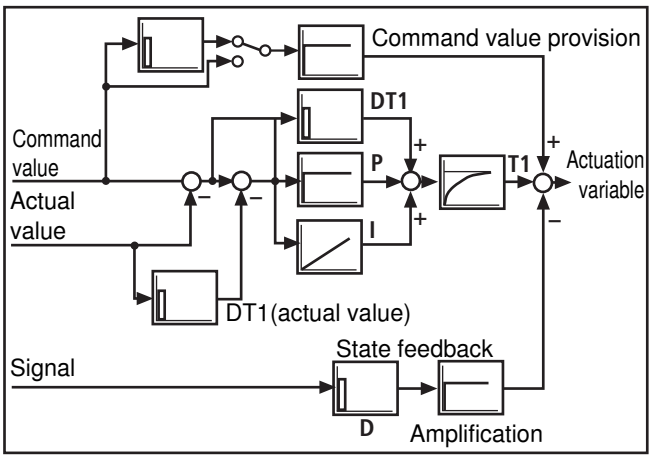
As actual value signal, you can use both, an SSI encoder or incremental encoder [2] digital measurement system or one or several analog sensors.

The controller structure is designed as PIDT1 controller, whereas each component can be activated or deactivated individually. In this way, you can, e.g. also realize a P or PT1 controller. The I component can moreover be controlled via a window (upper and lower limit).

Controller parameters can be set in a block-wise or in a block-independent form.

A state feedback can be used for dampening the controller output.

Controller structure:



Adjustment to hydraulic system

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

- Direction-dependent gain [10]

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

  In this way, the progressive flow characteristic of proportional directional valves is 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 troubleshooting

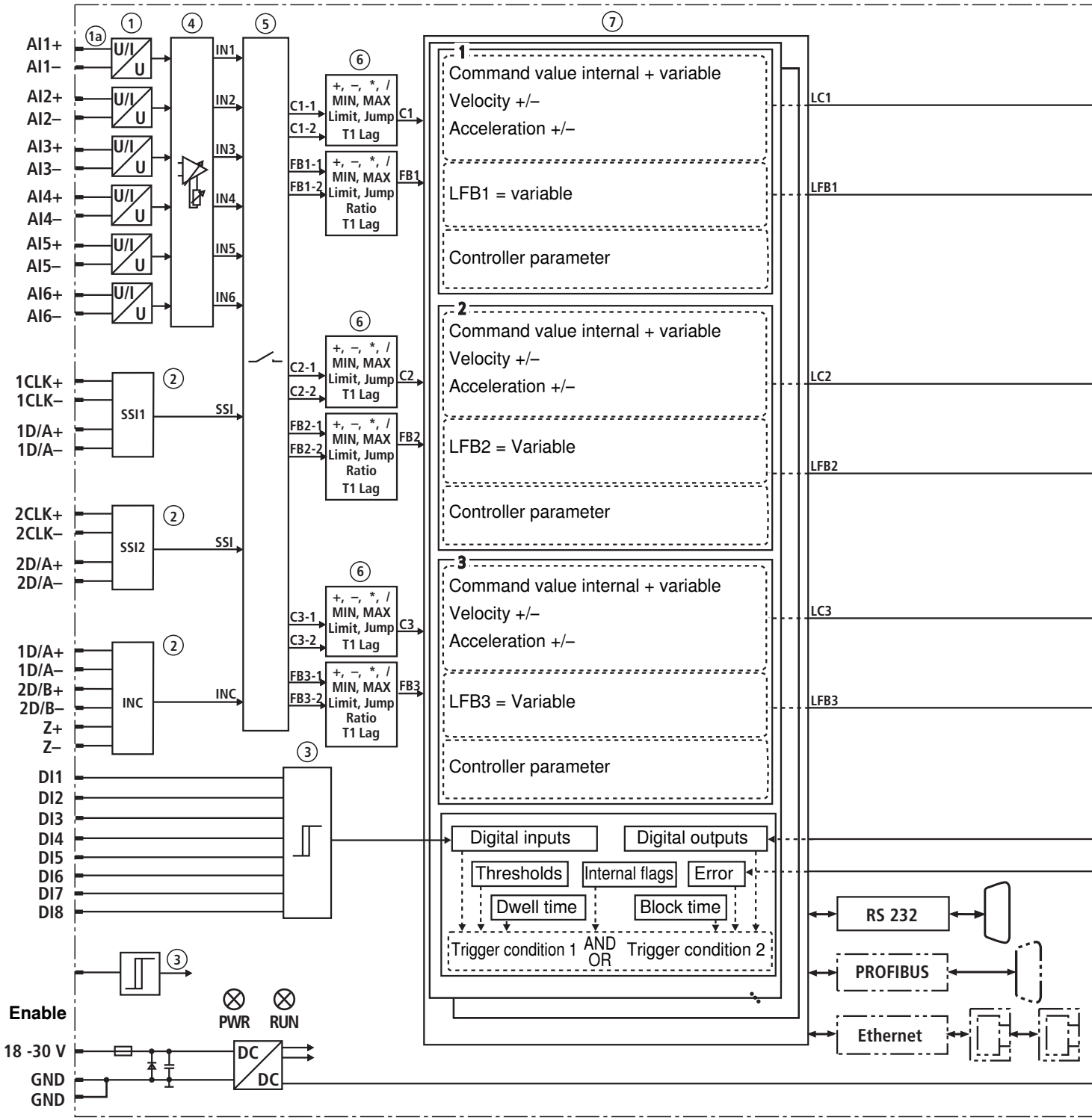
The HACD supports numerous error monitoring possibilities:

- Monitoring of the analog inputs for undershooting or exceedance of the range
- Monitoring of the sensors for cable break
- Control error monitoring in case of configuration of the HACD as controller
- Monitoring of the supply voltage, all internal voltages as well as of the +10 V reference voltage
- Monitoring of the microcontroller itself (watchdog) as well as of the accumulator (check sum)

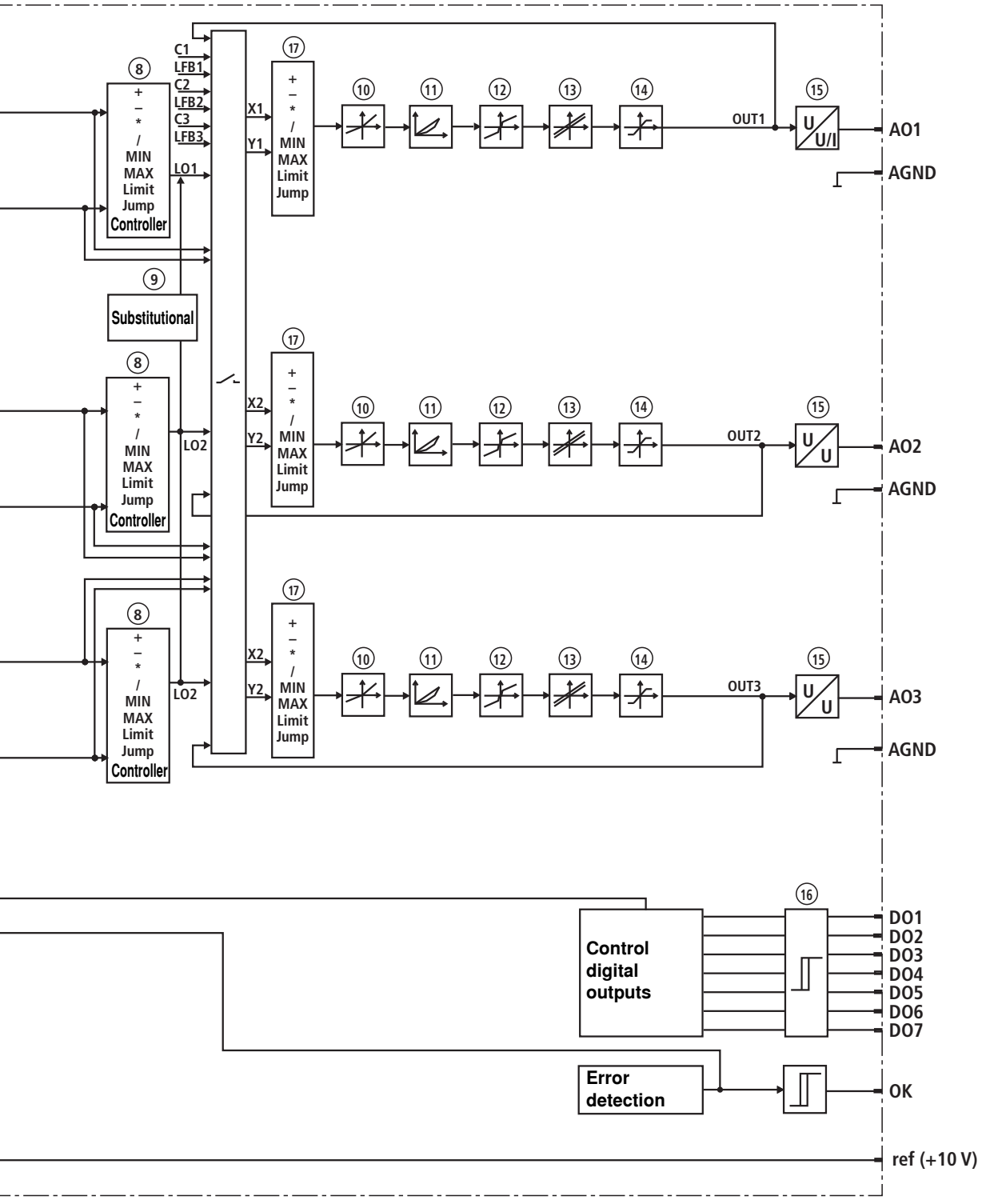
The error monitors as well as their reaction can be configured, as well.

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

Block diagram: Mode 3 - structural editor



1 Analog inputs voltage or current
1a High-impedance input AI1
2 SSI or incremental
3 Release input and digital inputs
4 Adjustment analog inputs
5 Switching matrix
6 Math. linking of the inputs
7 32 blocks for command value generation, controller parameter switching
8 Math. linking and/or controller
9 Substitutional closed-loop control
10 Direction-dependent gain
11 Characteristic curve adjustment



12 Residual velocity and overlap jump
13 Offset
14 Limitation
15 Analog outputs voltage or current
16 OK output and digital outputs
17 Math. linking of the outputs

System overview, interfaces

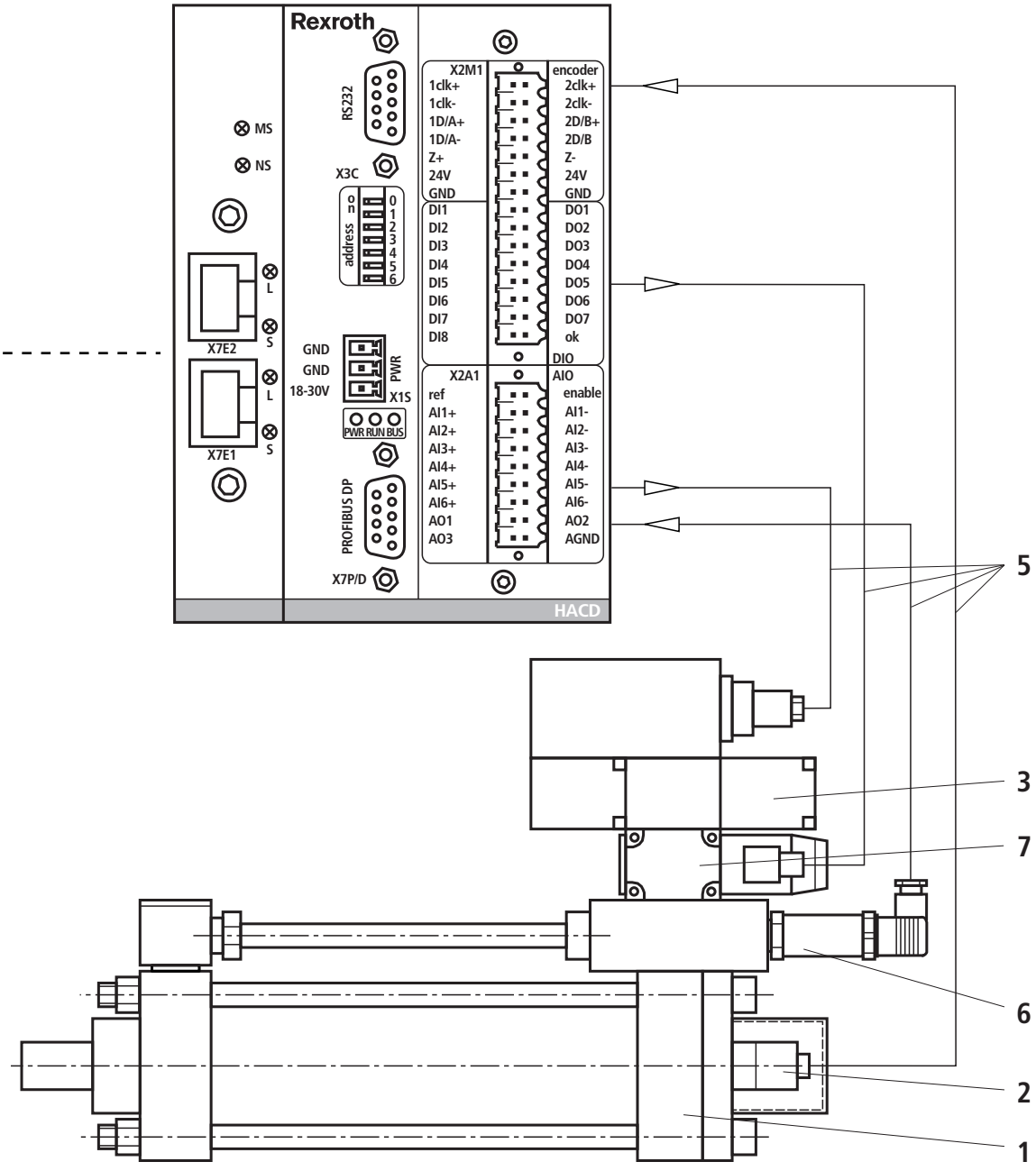
Superior control

Possible interfaces with the VT-HACD-3-2X:

- Analog signals
- Digital inputs / outputs
- Serial interface
- Bus systems

Example:

VT-HACD-3-2X/… with hydraulic cylinder axis



1 Single-rod 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 isolator valve (with plug-in switching amplifier)

Technical data

Operating voltage [1]	U_B	18 to 30 VDC
Current consumption at 24 VDC		200 mA (observe additional 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 analyzable)
• 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 24 V encoder supply is implemented directly via the VT-HACD-3-2X (supply voltage is looped in), the transducer specification has to be observed.

Technical data, (continued)

X3C, Interface for BODAC		RS232
X7P, Bus interface		PROFIBUS DP (max. 12 MBaud according to IEC 61158)
X7E1(2), Ethernet interface		PROFINET RT, EtherNet/IP
Switching inputs (DI) and/or outputs (DO)		
	Quantity	DI = 9 / D0 = 8
Gate inputs (DI)	Logic level	log 0 (low) ≤ 5 V; log 1 (high) ≥ 10 V to U_B, I_e = 7 mA at U_B = 24 V
	Port	Flexible conductor up to 1.5 mm²
Gate outputs (DO)	Logic level	log 0 (low) ≤ 2 V; log 1 (high) ≤ U_B; I_{max} = 20 mA, Maximum load capacity C = 0.047µF
	Port	Flexible conductor up to 1.5 mm²
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. 28 Bit
• Line receiver / line driver		RS485
– Voltage supply for SSI transducer via the 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
Installation		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 module	*m*	930 g
with EtherNet module	*m*	1162 g
CE conformity		See page 2

Further technical details upon request.

Note:

Information on the **environment simulation testing** for the areas EMC (electromagnetic compatibility), climate and mechanical load see data sheet 30543-U.

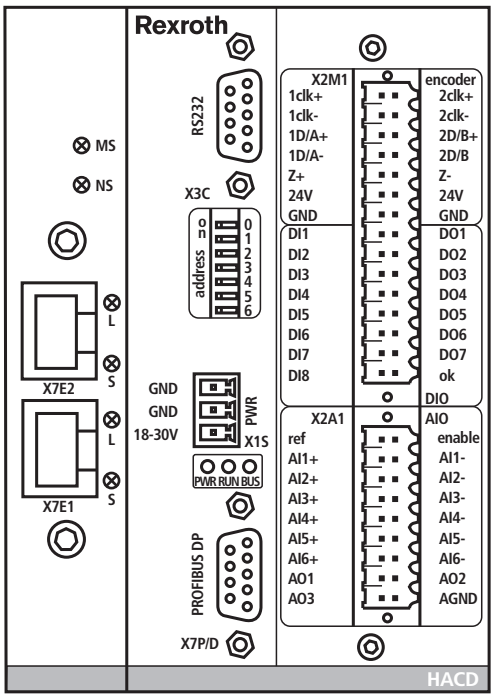
Pinout

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

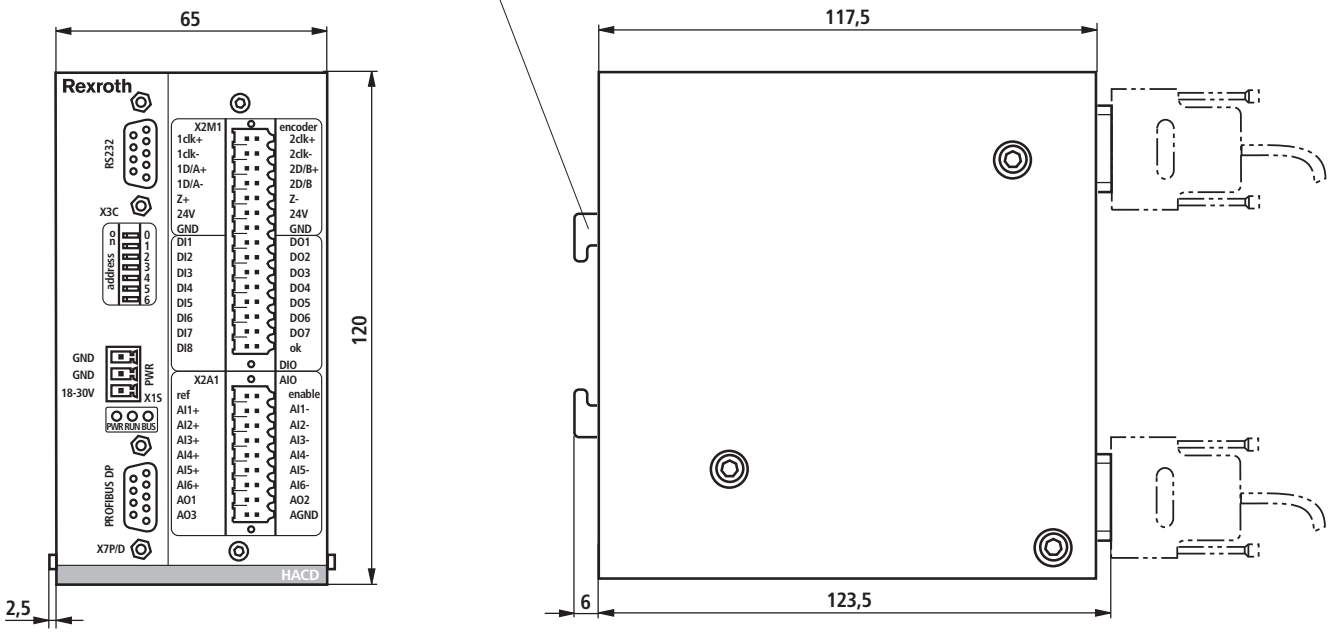
Notes:

- The pins marked with **"reserved"** are reserved and must not be wired!
- PROFIBUS DP (port X7P/D) is not available with the Ethernet version.

Unit dimensions (dimensions in mm)

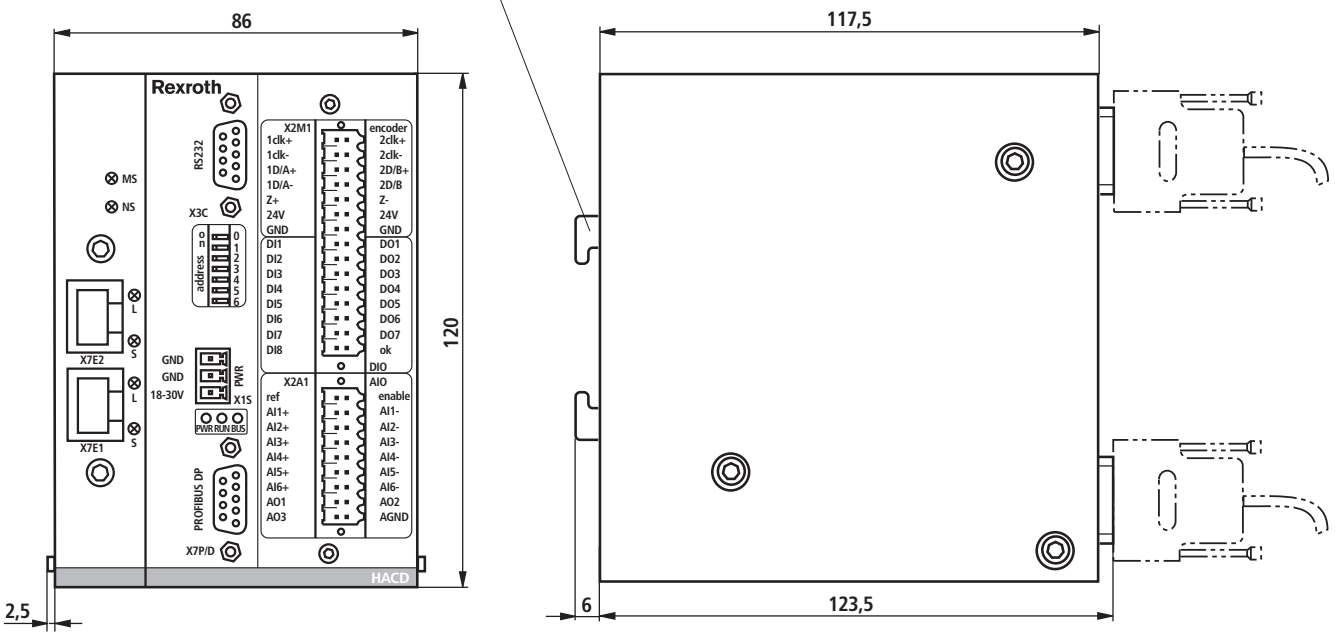
VT-HACD-3-2X/ (without Ethernet**)**

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



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

Installation 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

Start-up PROFIBUS Interface 30543-01-Z

Start-up EtherNet/IP Interface 30543-04-Z

Start-up 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 units can be repaired. The repaired units will be supplied with default settings. User-specific settings are not maintained. The operator will have to re-transfer the corresponding user parameters and programs.

Notes:

- Electric signals taken out via control electronics (e.g. signal “No error”) may not be used for the actuation of safety-relevant machine functions! (See also the European standard “Safety requirements for fluid power systems and their components - Hydraulics”, EN 982.)
- If electromagnetic interference must be expected, take appropriate measures to safeguard the function (depending on the application, e.g. screening, filtration)!
- For more information refer to the BODAC software description 30543-01-B and the 30543-B operating instructions
- The upper and lower ventilation slots must not be concealed by adjacent units in order to provide for sufficient cooling.

Notes

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