

SIEMENS

BACnet MS/TP



OpenAir™
VAV Compact Controller BACnet MS/TP
G..B181.1E/BA

Technical Basics

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Table of contents

1	Introduction.....	4
1.1	Revision history	4
1.2	Before you start	4
1.3	Objectives of this basic documentation.....	5
1.4	Abbreviations and naming conventions	5
1.5	Referenced documents	5
2	Device.....	6
2.1	Type summary	6
2.2	Design and device parts.....	9
2.3	Dimensions.....	9
2.4	Human-machine interface	10
2.5	Internal diagrams.....	12
3	Measuring principle	13
4	Functionality / application	14
4.1	Fields of application	14
4.2	Application examples.....	14
4.3	Demand-controlled ventilation (DCV)	15
5	Electrical and mechanical installation	16
5.1	Mechanical installation / mounting.....	16
5.2	Electrical installation / cabling	17
6	Parameterization and operating modes.....	19
6.1	Settings and user interaction.....	19
6.2	Configuration and maintenance tools	21
6.3	Setting examples	22
7	Engineering and commissioning	26
7.1	Fundamentals / environments	26
7.2	Engineering	26
7.3	Commissioning	26
8	Safety and EMC optimization	28
8.1	Safety notes	28
8.2	Device-specific regulations	29
8.3	Notes on EMC optimization.....	30
9	Technical data.....	31
10	Datapoints and function description	33
10.1	BACnet Object List	33
10.2	Parameter and function description.....	36
11	Environmental compatibility and disposal	39

1 Introduction

1.1 Revision history

Version	Date	Changes	Section	Pages
b	2016-02-26	EU and RCM Conformity, European Directive 2012/19/EU	9 Technical data, 11 Environmental compatibility and disposal	32 39
a	2015-09-17	Initial release		

1.2 Before you start

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1.3 Objectives of this basic documentation

This basic documentation covers the networked VAV Compact Controllers G..B181.1E/BA. These devices are designed for controlling variable or constant air volume flows.

This document is structured along the according workflow. Following a description of the devices and their application, mounting, engineering, and commissioning are covered. A references section lists technical data, parameters, and data points.

1.4 Abbreviations and naming conventions

1.4.1 Abbreviations

Abbreviation	Description
VAV	Variable Air Volume
RTU	Remote Terminal Unit
CAV	Constant Air Volume

1.4.2 Naming conventions

Throughout this documentation the term “VAV compact controller(s)” refers to the GDB181.1E/.. (5 Nm nominal torque) as well as to the GLB181.1E/.. (10 Nm nominal torque).

1.5 Referenced documents

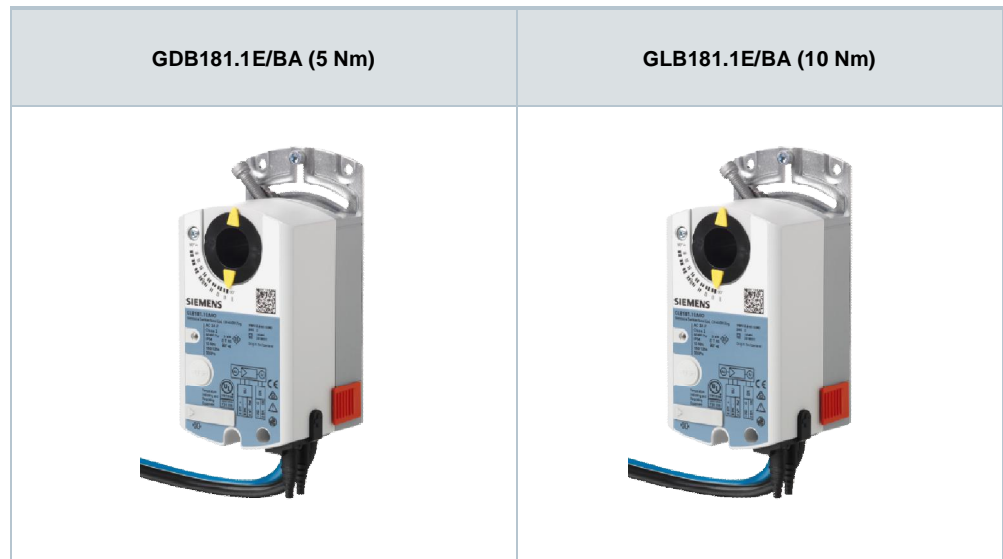
- [1] G..B181.1E/BA - VAV Compact Controller BACnet MS/TP - Datasheet (A6V10631832)
- [2] GxB181.1E/BA VAV Compact Controller BACnet MS/TP - BACnet Protocol Implementation Conformance Statement (PICS) (A6V10644636)
- [3] Mounting instruction for VAV Compact Controllers (A6V10523083)
- [4] AST20 - VAV Handheld Tool - Datasheet (A6V10631836)
- [5] AST20 - VAV Handheld Tool - Manual (A6V10555077)
- [6] AST11 - Interface Converter (N5852)
- [7] ACS931 - PC-Software for OEM - Datasheet (N5853)
- [8] ACS941 - PC-Software for Service - Datasheet (N5854)
- [9] Desigo™ - Ethernet, TCP/IP, MS/TP and BACnet: Technical principles (CM110666) - Chapter 7 and others
- [10] BACnet® - A Data Communication Protocol for Building Automation and Control Networks - ANSI/ASHRAE Standard 135-2008

2 Device

2.1 Type summary

2.1.1 Device variants, tools and accessories

VAV Compact Controller BACnet MS/TP



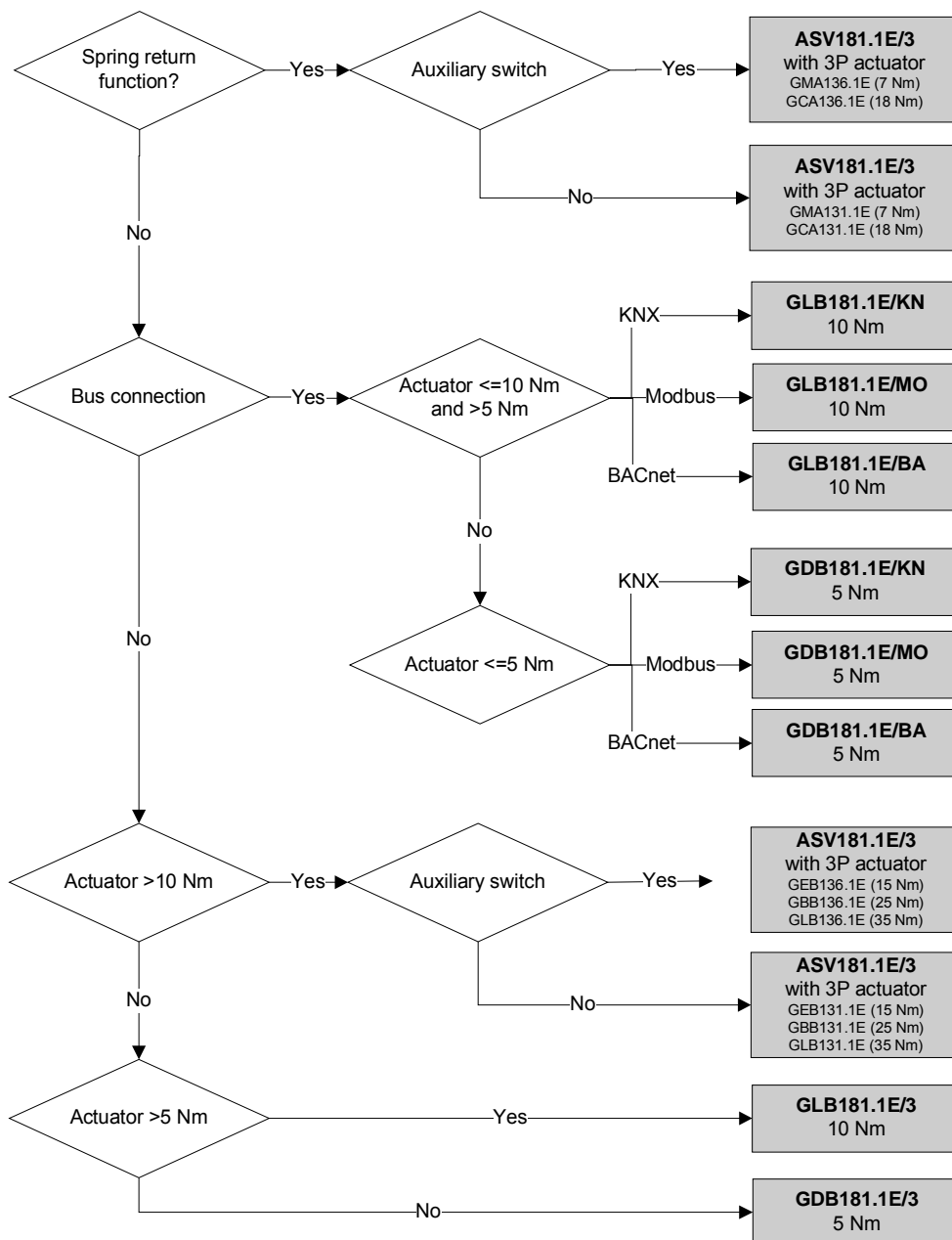
Tools for commissioning and service

AST20	ACS931 v6 / ACS941 v4
<p>The handheld tool AST20 can be used for status monitoring, VAV parameter setting, and bus configuration setting.</p>	<p>The PC software for service ACS941 can be used for setting and reading a certain set of device parameters (values set by OEM and current configuration, and actual values). For connecting to a PC with RS232 interface, an interface converter AST11 is required.</p>
<p>Datasheet: A6V10631836 Instructions: A6V10555077</p>	<p>Datasheet ACS941: N5854 Datasheet AST11: N5852</p>

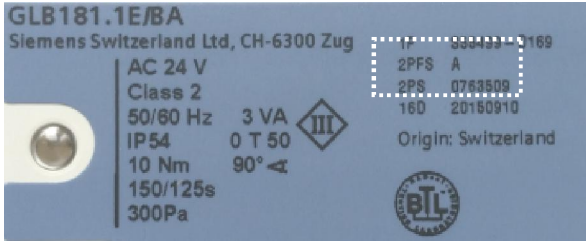
Accessories

For information regarding accessories and spare parts for VAV Compact Controllers, please refer to datasheet N4698.

2.1.2 Selection guide for all types



2.1.3 Version summary

Version	Series A
Identification	 <p>GLB181.1E/BA Siemens Switzerland Ltd, CH-6300 Zug</p> <p>AC 24 V Class 2 50/60 Hz IP54 10 Nm 150/125s 300Pa</p> <p>3 VA 0 T 50 90°-4</p> <p>III</p> <p>2PFS A 2PFS 0768800 160 20160910</p> <p>Origin: Switzerland</p> <p>BTL</p>
Features	<ul style="list-style-type: none"> ▪ Communication Modbus RTU or BACnet MS/TP ▪ Quasi-static differential pressure sensor. ▪ Simultaneous feedback of actual values of damper position and air volume flow. ▪ Optional adaptive opening range measurement (adaptive positioning). ▪ HMI with push button and LED.

2.2 Design and device parts

The VAV Compact Controllers consist of a differential pressure sensor, actuator and digitally configurable control electronics. They are intended for mounting on damper shafts of a minimum length of 30 mm. They consist of base and 2-sectional housing.

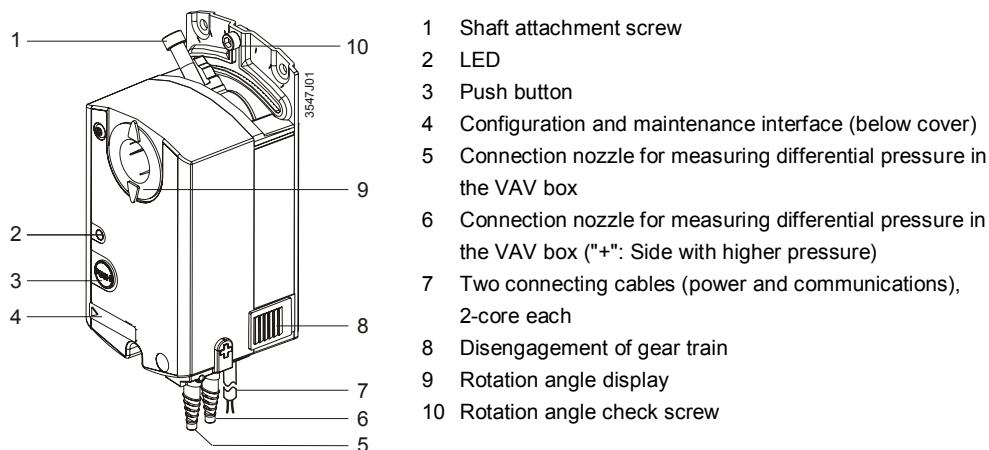
Components contained in the **base**:

- Steel base plate with damper drive shaft fixing for different drive shaft diameters / cross-sectional areas (cf. section 2.3) and angular rotation limiter,
- maintenance-free, low-noise gear train,
- magnetic hysteresis clutch with practically contact-free force transmission; this means that the actuator is locking- and overload-proof, also in continuous operation.

Components contained in the **housing** (Note: the housing cover can't be removed):

- controller electronics,
- differential pressure sensor,
- synchronous motor for the damper actuator.

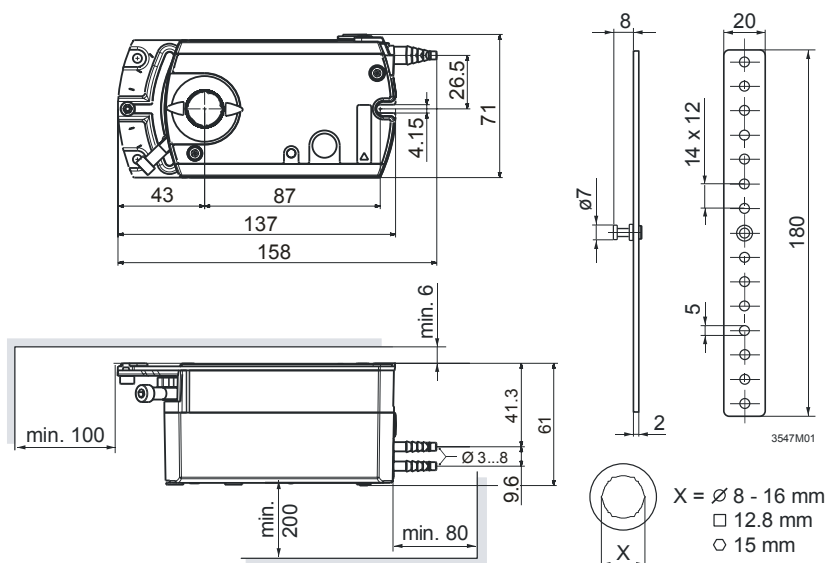
Main device parts



Gear train disengagement

Manual control of the air dampers is possible by gear train disengagement (8) when the VAV Compact Controller is disconnected from the power supply.

2.3 Dimensions



2.4 Human-machine interface

2.4.1 HMI parts and description

Push button operations

Activity	Push-button operation	Confirmation
Display current address (in backward order)	Press button < 1s	Current address is displayed
Enter push-button addressing mode	Press button > 1s and < 5s	Red LED shines (release button before LED gets dark)
Reset to OEM default settings	Press button > 10s	Orange LED flashes

LED colors and patterns

Color	Pattern	Description
Green	steady	Start-up
	1s on 5s off	Fault free operation ("life pulse")
Orange	flashing	Bus traffic
	1s on 5s off	Backup mode entered
Red	steady	Mechanical fault / device jammed
	flashing fast	Sensor error: Pressure tubes interchanged or „Invalid configuration“
	flashing slowly	Sensor error: Internal read error
	1s on 5s off	Internal error

2.4.2 Factory reset

Factory reset

The VAV Compact Controllers can be reset by push-button:

1. Press button for >10s → LED starts flashing **orange**
2. Release button while LED still flashes → LED keeps flashing for 3s
3. After those 3s → LED shines **red** (reset), then **green** (start-up).

A factory reset by push-button leads to a reset of all parameters as described in the section **6.1.1 Fehler! Verweisquelle konnte nicht gefunden werden.** to the OEM default values. Since these values can be set by the OEM, they are not necessarily the same as the Siemens factory settings.

All other parameters, especially the bus parameters, are reset to Siemens factory settings.

VAV Compact Controllers can also be reset by the VAV handheld tool AST20 or over bus. Please refer to the corresponding operating manual / technical basics.

2.4.3 Addressing by push-button

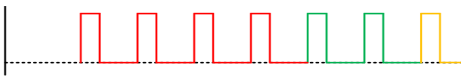
When using the AST20 handheld tool or the ACS941 PC tool, all bus parameters as well as most VAV controller parameters (VAV control parameters and actuator parameters) can be set.

The address of the VAV Compact Controller can be set without a separate tool by using the push-button and LED.

Display current address
(digits in reverse order)

To display the current address, press button <1s.

Colors		
1-digits: red	10-digits: green	100-digits: orange

Example for address 124:	
LED	
Note	The address is entered and shown in reverse order.

Set new address

1. **Enter addressing mode:** press button > 1s until LED shines **red**, then release button (before LED gets dark).
2. **Enter digits:** press button n-times → LED flashes per button press (feedback).
 - Colors: 1-digits: **red** / 10-digits: **green** / 100-digits: **orange**
3. **Store digits:** hold button pressed until LED shines in color of following digits – release button,
4. **Save whole address:** hold button pressed until LED shines **red** (address confirmation) → release button¹.
 - An address can be stored at any time, i.e. after setting the 1-digits, or after setting the 1- and the 10-digits.
5. Entered address is repeated one times for confirmation.

Examples

Set address “124”:

1. Enter addressing mode
2. Set 1-digits: Press button 4-times → LED flashes **red** per button press
3. Store 1-digits: press button until LED shines **green** – release button
4. Set 10-digits: Press button 2-times → LED flashes **green** per button press
5. Store 10-digits: press button until LED shines **orange** – release button
6. Set 100-digits: Press button 1-times → LED flashes **orange** per button press
7. Store address: press button until LED shines **red** – release button
→ address is stored and displayed 1x for confirmation.

Set address “50”:

1. Enter addressing mode
2. Skip 1-digits: Hold button pressed until LED shines **green** – release button
3. Set 10-digits: Press button 5-times → LED flashes **green** per button press
4. Store address (skip 100-digits): hold button pressed until LED shines **red** – release button
→ address is stored and displayed 1x for confirmation.

Set address “9”:

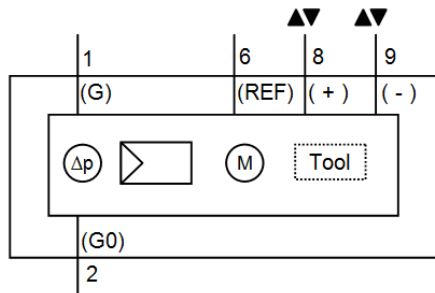
1. Enter addressing mode
2. Set 1-digits: Press button 5-times → LED flashes **green** per button press
3. Store address: press button until LED shines **red**
→ address is stored and displayed 1x for confirmation.

¹ Note: If button is released before LED shines yellow, the address is discarded.

2.5 Internal diagrams

The VAV Compact Controller is supplied with two prewired connecting and communication cables. All interconnected devices must be connected to the same G0.

Internal diagram
(Applies to all types)



Tool = Configuration and maintenance interface
(7-pin)

Power supply and bus
cable (color coded and
labeled)

Core designation	Core color	Terminal code	Description
Cable 1: Power / black sheathing			
1	red (RD)	G	System voltage AC 24 V
2	black (BK)	G0	System neutral AC 24 V
Cable 2: Communication / blue sheathing			
6	violet (VT)	REF	Reference
8	grey (GY)	+	Bus (BACnet MS/TP)
9	pink (PK)	-	Bus (BACnet MS/TP)

Note

Terminal layout may differ for each device. Devices with twin-terminals or internally connected terminals may be encountered as well as bus connection in junction boxes. Please refer to the technical basic documentation for product specific information.

- The operating voltage at terminals G and G0 must comply with the requirements under SELV or PELV.
- Safety transformers with twofold insulation as per EN 61558 required; they must be designed to be on 100 % of the time.

3 Measuring principle

A measuring device for acquiring the differential pressure – usually a measuring cross, measuring orifice or Venturi tube in the airflow – represents the basis for air volume flow measurement.

Differential pressure sensor

The air volume flow is measured indirectly with a differential pressure sensor. Since the measured value is the differential pressure Δp , the air flow is derived from this value using the VAV box characteristic. Accordingly, the VAV box OEM has to provide the combination of Δp_n and V_{nom} , out of which the air volume flow in m^3/h or l/s can be calculated.

The air volume flow value (relative or absolute) can be transmitted over the bus together with the actual value of the damper position (in %) to be used by a supervisory controller or for management purposes. The differential pressure sensor operates long-term stable and without recalibration.

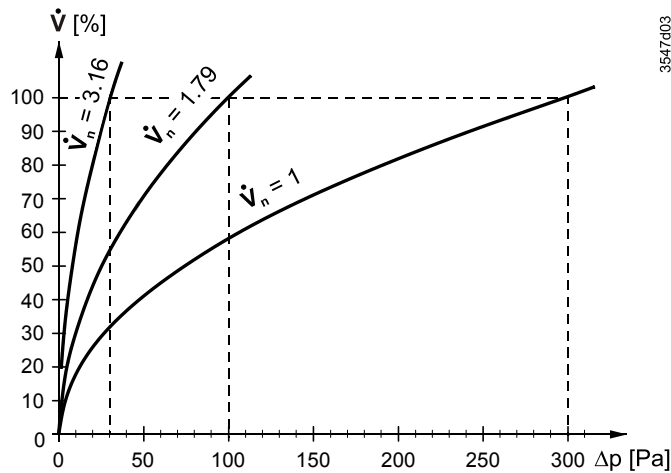
Note

In critical cases material compatibility tests should be made while giving consideration to harmful substances and concentrations.

Setting the characteristic value V_n

The parameter V_n is used to adjust the operating range of the differential pressure sensor (0...300 Pa) to the actual VAV box nominal pressure Δp_n at the factory. The effect of V_n is illustrated in the diagram below.

Effect of V_n



Calculation of V_n
(Δp_n = nominal pressure)

$$V_n = \sqrt{\frac{300 \text{ Pa}}{\Delta p_n \text{ Pa}}}$$

Calculation example

Assume that a VAV box is designed for a nominal pressure of $\Delta p_n = 120 \text{ Pa}$. Then, V_n has to be set to 1.58:

$$V_n = \sqrt{\frac{300 \text{ Pa}}{120 \text{ Pa}}} = \sqrt{2.5} = 1.58$$

4 Functionality / application

4.1 Fields of application

Application

VAV Compact Controllers are primarily used for controlling a variable or constant air volume flow.

System environments:

- Building automation systems using BACnet MS/TP (third-party integration and freely programmable devices)

Application fields:

- Supply air control
- Extract air control
- Supply/extract cascade control with
 - Ratio control 1:1
 - Ratio control (positive/negative pressure)
 - Differential control (positive/negative pressure)
- Air dampers with a nominal torque of up to 5 or 10 Nm

Note

VAV Compact Controllers are not suitable for environments where the air is saturated with sticky or fatty particles or contain aggressive substances.

4.2 Application examples

VAV Compact Controller with BACnet MS/TP communication can be used for any supply and extract air control application, and be used in demand-controlled ventilation (DCV) systems when using a connection to the air-handling unit (AHU) control. The examples focus on the communication part of the applications. Other devices such as electrical heaters with connection independent of the BACnet MS/TP configuration may not be shown.

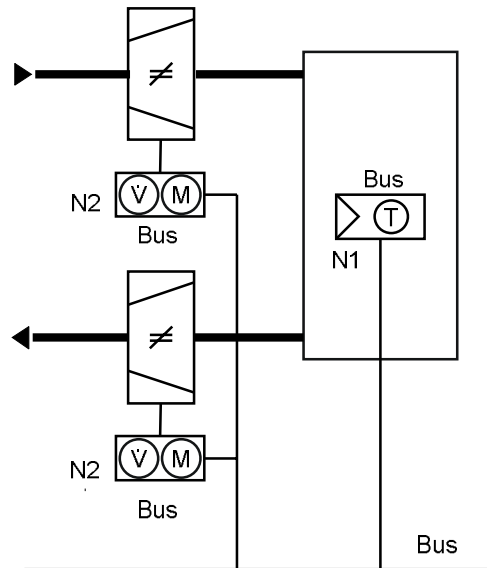
Control of air volume flow in supervisory controller

Fundamental of all applications realized with VAV Compact Controllers is the principle to control the air volume flow in the supervisory controller.

4.2.1 Supply and extract air control

Supply / extract air control

If one VAV Compact Controller is used for supply air and one for extract air, these are usually controlled individually by the supervisory controller. By setting their volume flow limits (V_{\min} and V_{\max}) according to the setting instructions in section 6.3, constant, positive or negative pressure in a zone or a room can be achieved.



Legend:

- Bus Fieldbus (Modbus, BACnet, KNX etc.)
- N1 Room unit with temp. sensor
- N2 VAV Compact Controllers (supply air / extract air)

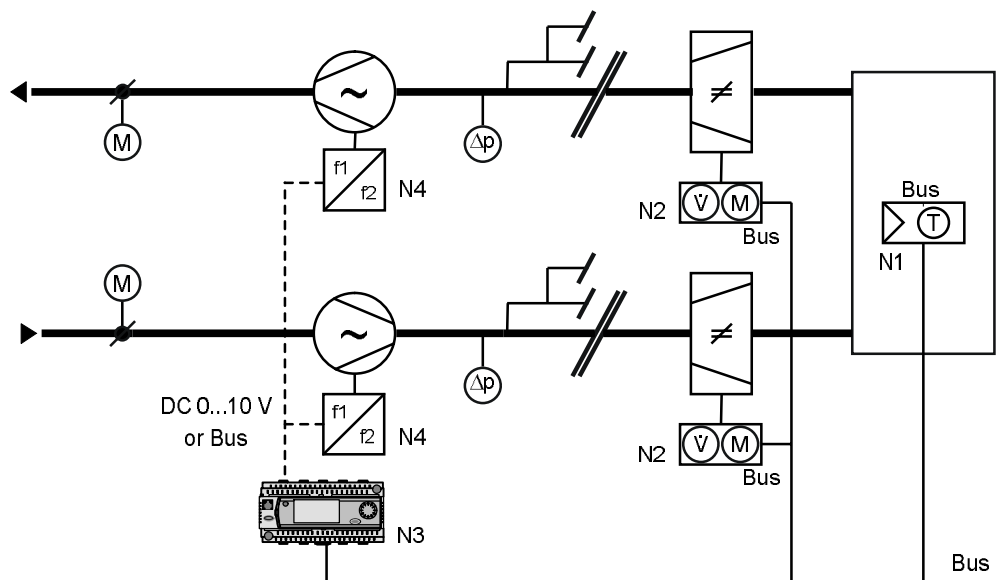
When omitting the extract air part, a simple supply air control application can be realized. Disadvantages are that ventilation conditions in the room or zone can't be controlled precisely.

4.3 Demand-controlled ventilation (DCV)

Example: AHU control optimization

In combination with a suitable supervisory room controller, an AHU control optimization algorithm can be run using the actual value of the damper position feedback signal.

The control of variable speed drives (VSDs) can be accomplished by various means. Below depicted is DC 0...10 V control, but plants with USS- or BACnet MS/TP-controlled VSDs are also possible, depending on the connector layout of the universal / primary controller.



Legend:

- Bus Fieldbus (Modbus, BACnet, KNX etc.)
- N1 Room unit with temp. sensor
- N2 VAV Compact Controllers (supply / extract air)
- N3 Universal / primary controller
- N4 Variable Speed Drives (VSD)

5 Electrical and mechanical installation

5.1 Mechanical installation / mounting

Mounting and mounting limitations

For mounting and limitations on mounting (location / position), consulting the mounting instruction [3] is mandatory.

Environmental conditions

The permissible ambient temperature and ambient humidity must be observed (cf. section 9).

Manual control

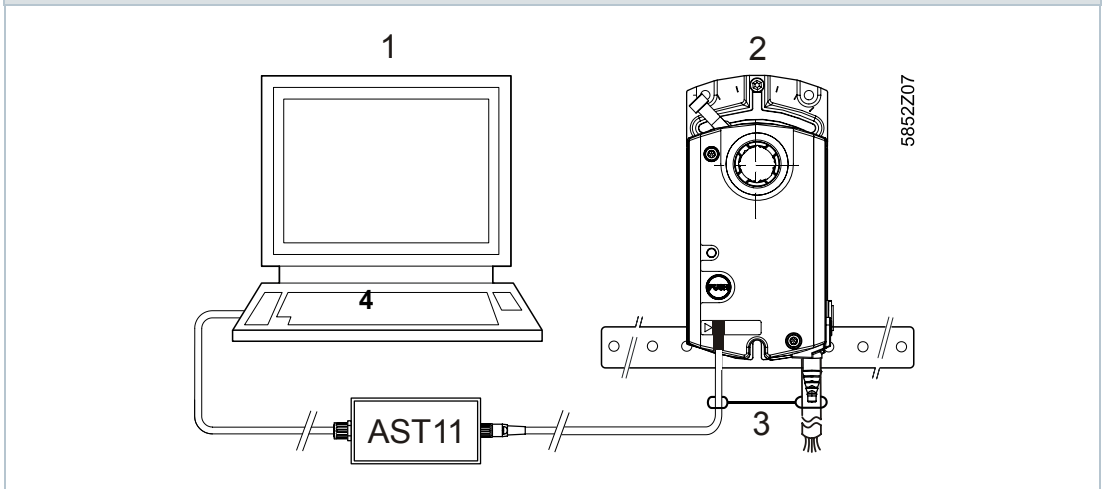
The actuator may only be manually operated when **separated from power supply**.

Mechanical limitation of angular rotation

If required, the angular rotation can be set by appropriate adjustment of the adjusting screw.

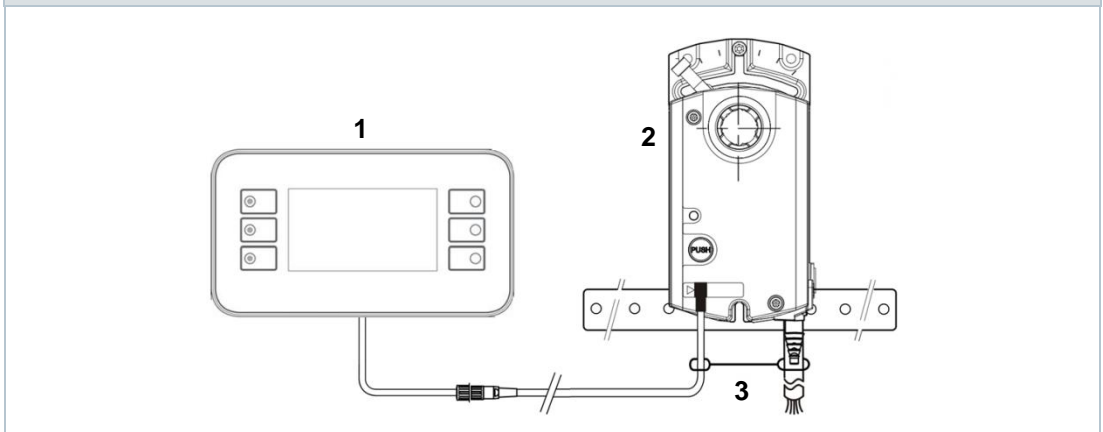
Configuration and maintenance interface

Connection of PC tool ACS931 / ACS941 to G..B181.1E/BA



- 1 PC (with ACS931 or ACS941)
- 2 G..B181.1E/BA
- 3 Strain release strip

Connection of VAV handheld tool AST20 to G..B181.1E/BA



- 1 AST20
- 2 G..B181.1E/BA
- 3 Strain release strip

5.2 Electrical installation / cabling

5.2.1 Power supply cabling

Permissible cable lengths and cross-sectional areas

The permissible cable lengths and cross-sectional areas depend on the actuators' current draw and the voltage drop on the connecting lines to the actuators. The necessary cable lengths can be determined from the following chart or with the help of the formulas. Cf. also to technical data in section 9.

Note

When determining the cable length and the cross-sectional area, it is to ensure that the permissible tolerances of the actuators' operating voltage are adhered to, in addition to the permissible voltage drop on the power supply and signal lines (see table below).

Permissible voltage drop

The cables are to be sized depending on the type of actuator used and based on the following data:

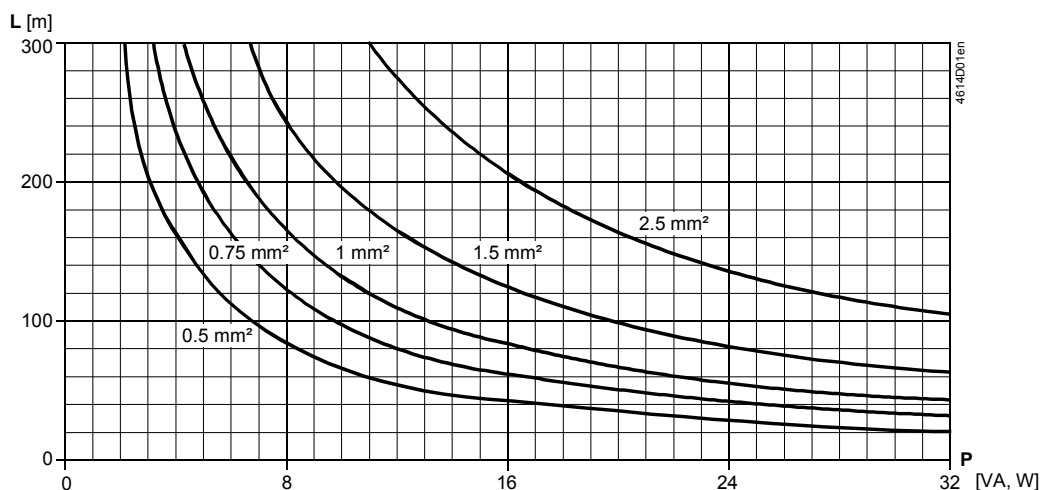
Type	Operating Voltage	Line	Max. permissible voltage drop
GDB181.. / GLB181..	AC 24 V	G0, G	System voltage AC 24 V

Note

The power supply voltage drop at AC 24 V must not exceed 8 % (4 % over the G0).

L/P chart for AC 24 V

The chart below applies to AC 24 V operating voltage and shows the permissible cable length L as a function of power P , and the cross-sectional areas as a parameter.

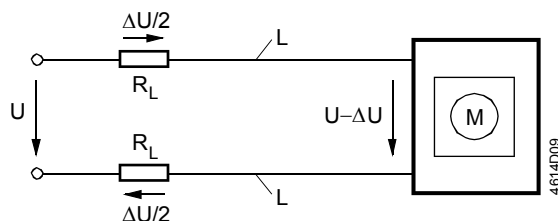


Note on chart

The values in [VA, W] on the P-abscissa are allocated to the permissible voltage drops ($\Delta U/2U = 4\%$) on line length L as per the above table and the basic diagram.

P is the decisive power consumption of all actuators connected in parallel.

Basic diagram:
Voltage drop on the supply lines



Formula for cable length

The following formula can be used to calculate the maximum cable lengths.

Operating Voltage	Permissible voltage drop	Formula for cable length
AC 24 V	4 % of AC 24 V	$L = \frac{1313 \cdot A}{P}$ [m]

- A Cross-sectional area in [mm²]
- L Permissible cable length in [m]
- P Power consumption in [VA] or [W];
refer to the actuator's type field

Example: Power consumption and permissible voltage drop (1 VAV controller)

Operating Voltage	Power consumption	Perm. voltage drop for line... 1 (G), 2 (G0)
AC 24 V	3 VA	4 % of AC 24 V

Example: Parallel connection of 4 actuators

Determine the cable lengths for 4 actuators operating on AC 24 V. Decisive for sizing the cable are only the AC currents on lines 1 (G) and 2 (G0). Maximum permissible voltage drop = **4 % per line**.

- Consumption = 4 x 3 VA = 12 VA
- Line current = 4 x 0.125 A = 0.5 A

Permissible single cable length for G and G0:

- 164 m with a cross-sectional area of 1.5 mm²
- 274 m with a cross-sectional area of 2.5 mm²

5.2.2 Bus cabling

Information regarding topology and addressing in BACnet MS/TP networks can be found in [9] and in [10]. The following sections presuppose electrical installations that conform to the protocol-specific requirements.

6 Parameterization and operating modes

6.1 Settings and user interaction

6.1.1 Device parameters

Parameterization

The OEM generally provides the basic configuration to VAV Compact Controllers, esp. the parameter V_n . The basic configuration is independent of the system environment where the VAV Compact Controllers are to be used.

For parameter setting, configuration and maintenance tools as described in section 6.2 are available. The following parameters must be checked or set prior to commissioning. Settings and changes have to be documented in the plant documentation.

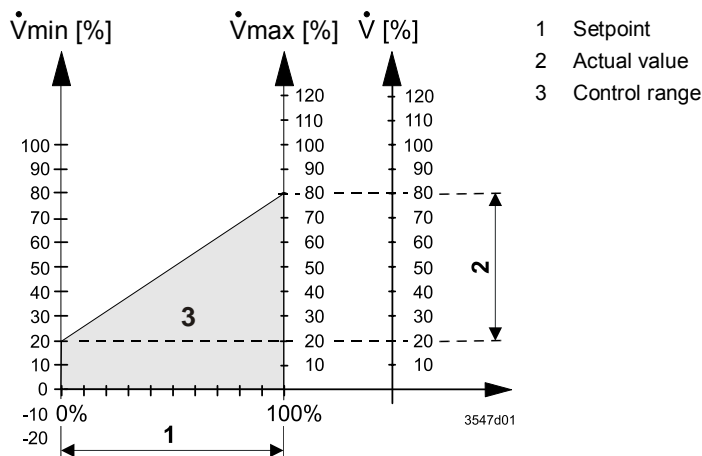
Parameter	Range	Description	Factory setting
Operating mode	VAV (flow ctrl.) / POS (position ctrl.)	Interpretation of setpoint VAV = Setpoint commands volume flow [%] POS = setpoint commands damper position [%]	VAV
Opening direction	CW (R) / CCW (L)	Opening direction of air damper	CW (R)
Adaptive positioning	Off / On	Adaption of actual opening range to position feedback Off = No adaption / mapping $0^\circ \dots 90^\circ \rightarrow 0..100\%$ On = Pos. adaption / mapping e.g. $0^\circ \dots 60^\circ \rightarrow 0..100\%$	Off
Vmax	20...120%	Maximum air volume flow	100 %
Vmin	-20...100%	Minimum air volume flow	0 %
Vnom	0...60'000 m ³ /h	Nominal air volume flow ²⁾	100 m ³ /h
Vn	1.00...3.16	Characteristic value for the air volume flow; set by the manufacturer (OEM)	1.00
Altitude	0...5000m in 500m steps	Altitude level correction factor for differential pressure sensor (select n*500m value closest to real altitude)	500 meters

Please refer section 10.2 for more explanation.

²⁾ Value used for displaying / not used for volume flow control loop

Variable air volume (VAV) control

VAV Compact Controllers operate in VAV mode when connected to the specified power supply. The setpoint signal determines the operating range $\dot{V}_{min} \dots \dot{V}_{max}$.



Constant air volume (CAV) control

The VAV Compact Controllers can be operated in CAV mode by setting the setpoint value accordingly, i.e. setting the supervisory controller to send a constant setpoint.

Position control

VAV Compact Controllers can also be operated as damper actuators, i.e. the 0...100% setpoint is interpreted as position setpoint, cf. section **10.2.6**.

6.1.2 Calculation formulas

The parameters are based on the following formulas:

Calculation of V_n
(Δp_n = nominal pressure)

$$V_n = \sqrt{\frac{300 \text{ Pa}}{\Delta p_n \text{ Pa}}}$$

300 Pa is the upper limit of the operating range of the differential pressure sensor. The nominal pressure is the differential pressure in the VAV box at a given nominal volume flow, determined by the OEM specification, cf. also section **3**.

Min. and max. values

$$V_{\min} [\%] = \frac{\text{min. volume flow} [\text{m}^3/\text{h}]}{\text{nom. volume flow} [\text{m}^3/\text{h}]} \cdot 100 [\%]$$

$$V_{\max} [\%] = \frac{\text{max. volume flow} [\text{m}^3/\text{h}]}{\text{nom. volume flow} [\text{m}^3/\text{h}]} \cdot 100 [\%]$$

Actual value as function of setpoint and min. / max. limits

$$\text{Actual value} [\%] = \frac{\text{Setpoint} [\%] \cdot (V_{\max} - V_{\min}) [\%]}{100 [\%]} + V_{\min} [\%]$$

Actual value as function of differential pressure

$$\text{FLW} [\%] = f(\Delta p) = 100 [\%] \cdot V_n \cdot \sqrt{\frac{\Delta p [\text{Pa}]}{300 [\text{Pa}]}}$$

Differential pressure as function of actual value

$$\Delta p [\text{Pa}] = f(\text{FLW}) = 300 [\text{Pa}] \cdot \left(\frac{\text{FLW} [\%]}{100 \cdot V_n} \right)^2$$

6.2 Configuration and maintenance tools

Configuration and retrieval of device parameters can be accomplished with the following tools:

- Using the PC software ACS941 or ACS931 together with the interface converter AST11 via the configuration and maintenance interface of the VAV Compact Controller or
- Using the handheld tool AST20.

6.2.1 PC software ACS941 and ACS931

Areas of use

The PC software ACS941 is designed for service and maintenance staff and is used for setting and displaying the parameter values on a PC. Instructions for use of this software can be found in datasheet N5854 ([8]).

The PC software ACS941 allows to set or to display the basic VAV parameters used during operation. The OEM default values are protected against unauthorized changes. The software supports trend functions and allows comparing the values set by the OEM with the values currently stored in the device. Thus, manipulations by parties other than the OEM can be detected.

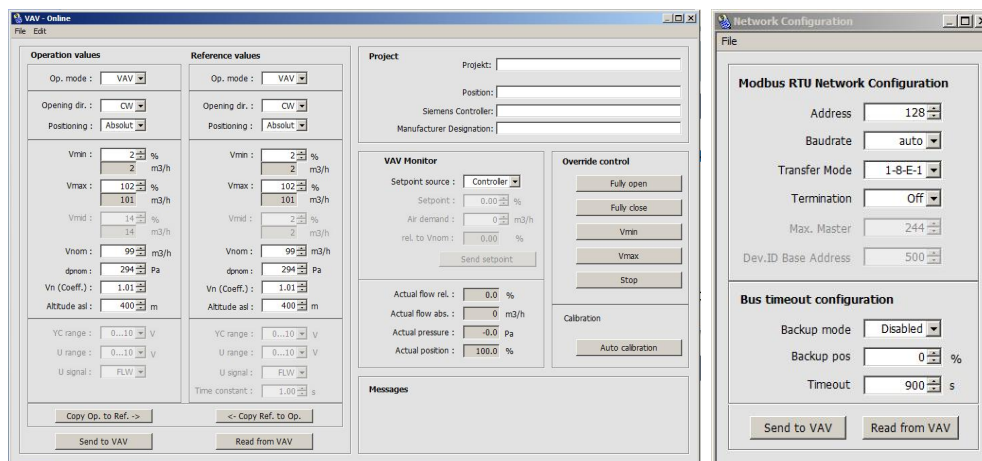


Figure 1: ACS941 with VAV (left) and network (right) configuration pane

Next to the PC software ACS941, an OEM version ACS931 [7] with extended functionality is available as well. ACS931 allows setting the parameter V_n and changing the OEM default values.

6.2.2 Handheld tool AST20

Functionality

Using the handheld tool AST20, VAV and BACnet MS/TP parameters can be set or retrieved. Instructions for use of the handheld tool AST20 can be found in the data sheet [4] and in the manual [5].

Design

The AST20 is designed for portable use on-site. Power supply and establishing the communication between AST20 and a VAV Compact Controller are realized with a 3-core connection cable.

6.3 Setting examples

6.3.1 Symbols and parameters

Volume symbols with “point” (\dot{V}) and without point (V) shall have the same meaning, i.e., they all shall refer to volume flows.

Legend to the setting examples

\dot{V}	Volume flow [%]
\dot{V}_{\min}	Minimum volume flow [%]
\dot{V}_{\max}	Maximum volume flow [%]
$\dot{V}_{\text{supply_air}}$	Volume flow of supply air controller [%]
$\dot{V}_{\text{extract_air}}$	Volume flow of extract air controller [%]
\dot{V}_{master}	Volume flow of supply air controller (Master) [%]
\dot{V}_{slave}	Volume flow of extract air controller (Slave) [%]

6.3.2 Min/max control by the supervisory controller

When setting the minimum / maximum air volume flow in the supervisory controller, the VAV Compact Controller has to be configured with $\dot{V}_{\min} = 0\%$ and $\dot{V}_{\max} = 100\%$.

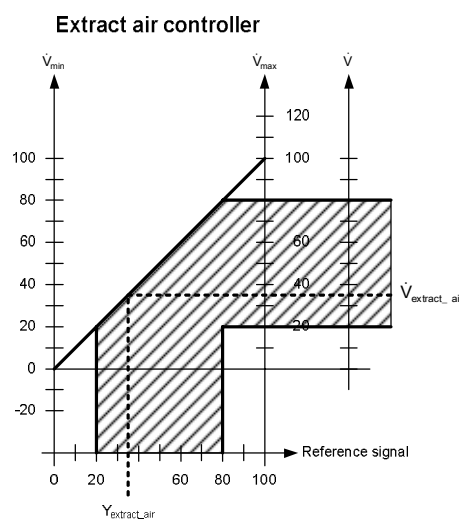
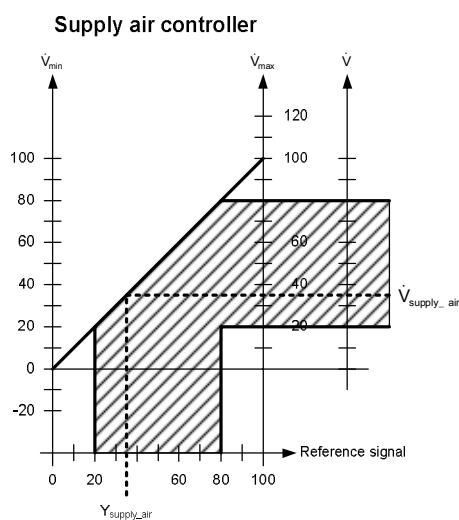
Setting example A1

VAV ratio control 1 : 1

	Supply air		Extract air	
	Vmin	Vmax	Vmin	Vmax
Supervisory controller	20 %	80 %	20 %	80 %
VAV Compact Controller	0 %	100 %	0 %	100 %

Reference signal: $Y_{\text{supply_air}} = Y_{\text{extract_air}} = 35\%$

Result: $V_{\text{supply_air}} = V_{\text{extract_air}} = 35\%$



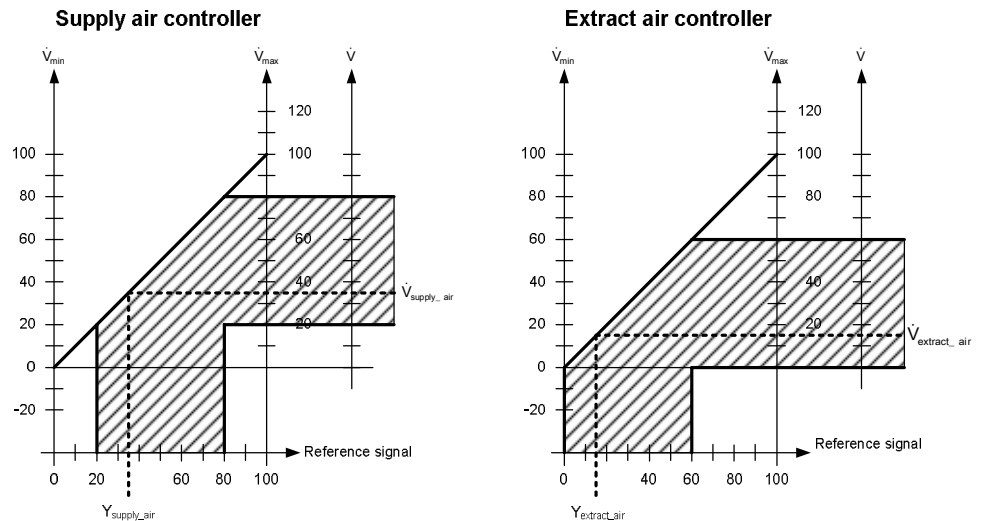
Setting example A2

VAV ratio control, 20 % constant excess supply air volume flow (positive pressure in the room)

	Supply air		Extract air	
	Vmin	Vmax	Vmin	Vmax
Supervisory controller	20 %	80 %	0 %	60 %
VAV Compact Controller	0 %	100 %	0 %	100 %

Reference signal: $Y_{\text{supply_air}} = 35 \%$, $Y_{\text{extract_air}} = Y_{\text{supply_air}} - 20 \% = 15 \%$

Result: $V_{\text{supply_air}} = 35 \%$, $V_{\text{extract_air}} = 15 \%$



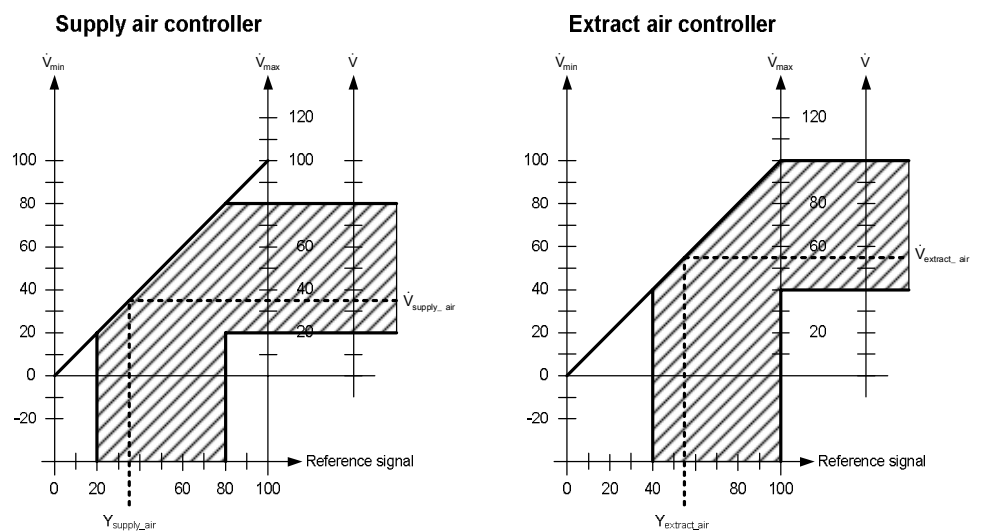
Setting example A3

VAV ratio control, 20 % constant excess extract air volume flow (negative pressure in the room)

	Supply air		Extract air	
	Vmin	Vmax	Vmin	Vmax
Supervisory controller	20 %	80 %	40 %	100 %
VAV Compact Controller	0 %	100 %	0 %	100 %

Reference signal: $Y_{\text{supply_air}} = 35 \%$, $Y_{\text{extract_air}} = Y_{\text{supply_air}} + 20 \% = 55 \%$

Result: $V_{\text{supply_air}} = 35 \%$, $V_{\text{extract_air}} = 55 \%$



6.3.3 Min/max control by the VAV Compact Controller

When setting the minimum / maximum air volume flow in the VAV Compact Controller, the supervisory controller must be set to $V_{\min} = 0\%$ und $V_{\max} = 100\%$. With this setting, the supervisory controller reference signal for both the supply air and extract air controller is the same. Thus, supply air / extract air control with a single reference signal is possible.

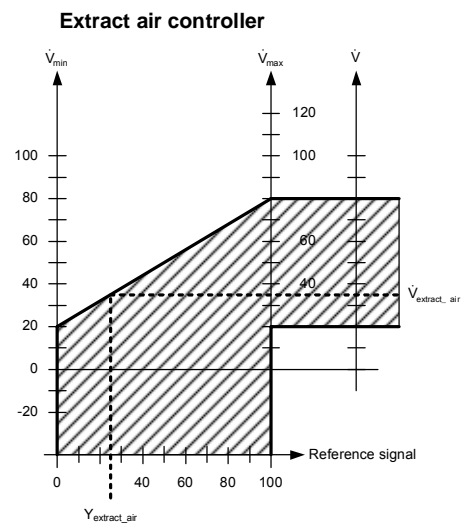
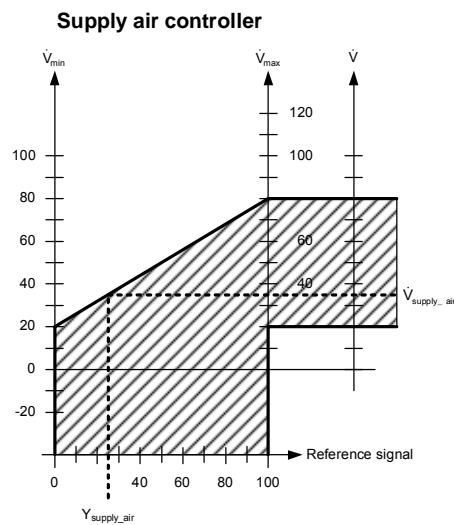
Setting example B1

VAV ratio control 1 : 1

	Supply air		Extract air	
	Vmin	Vmax	Vmin	Vmax
Supervisory controller	0 %	100 %	0 %	100 %
VAV compact controller	20 %	80 %	20 %	80 %

Reference signal: $Y_{\text{supply_air}} = Y_{\text{extract_air}} = 25\%$

Result: $V_{\text{supply_air}} = V_{\text{extract_air}} = 35\%$



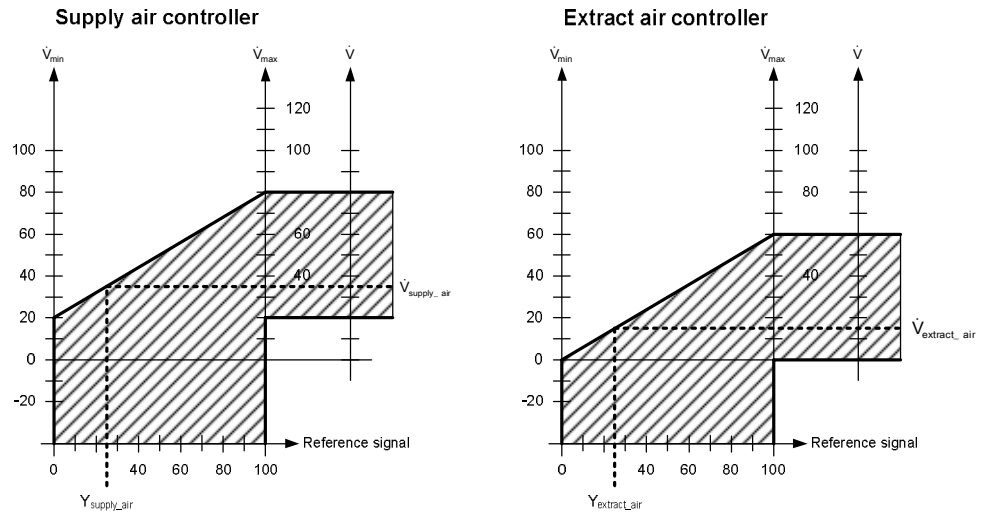
Setting example B2

VAV ratio control, 20 % constant excess supply air volume flow (positive pressure in the room)

	Supply air		Extract air	
	Vmin	Vmax	Vmin	Vmax
Supervisory controller	0 %	100 %	0 %	100 %
VAV Compact Controller	20 %	80 %	0 %	60 %

Reference signal: $Y_{\text{supply_air}} = Y_{\text{extract_air}} = 25 \%$

Result: $V_{\text{supply_air}} = 35 \%$, $V_{\text{extract_air}} = 15 \%$



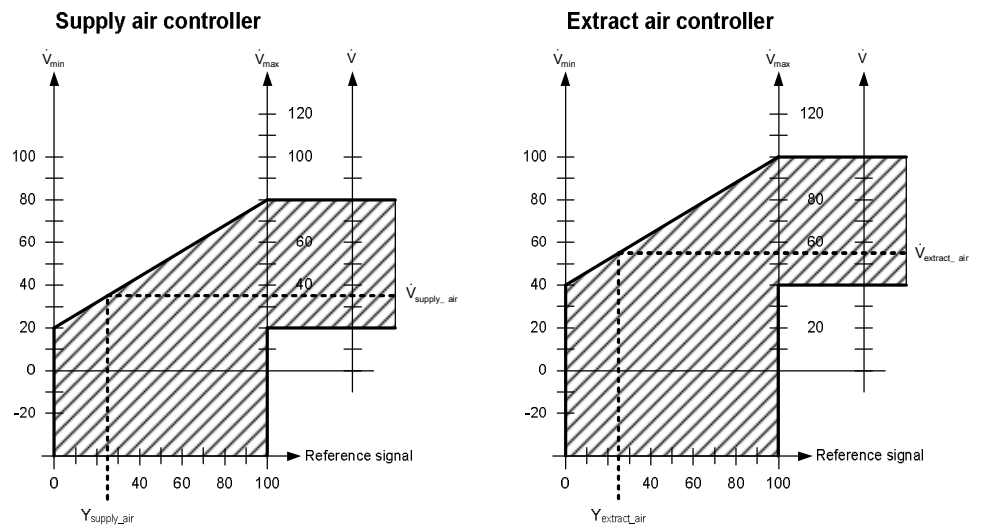
Setting example B3

VAV ratio control, 20 % constant excess extract air volume flow (negative pressure in the room)

	Supply air		Extract air	
	Vmin	Vmax	Vmin	Vmax
Supervisory controller	0 %	100 %	0 %	100 %
VAV Compact Controller	20 %	80 %	40 %	60 %

Reference signal: $Y_{\text{supply_air}} = Y_{\text{extract_air}} = 25 \%$

Result: $V_{\text{supply_air}} = 35 \%$, $V_{\text{extract_air}} = 55 \%$



7 Engineering and commissioning

7.1 Fundamentals / environments

Preconditions

For this chapter, sufficient knowledge about BACnet MS/TP communication and suitable controllers are presupposed, cf. [9] and [10].

7.2 Engineering

In case of VAV controllers with BACnet MS/TP, the task of engineering primarily refers to the implementation of the data model into a VAV application, especially the sending of the setpoint from the room controller to the VAV controller, and receiving the actual values (flow and position). The concrete workflow depends on the controller used.

The data model is documented in section 10 and in the PICS [2].

7.3 Commissioning

7.3.1 Preconditions

Commissioning requirements

The beginning of the commissioning phase assumes that all VAV Compact Controllers are mounted according to the mounting instruction [3] as well as all other devices according to their mounting instructions.

All devices must be connected to the power supply and bus cabling. Power supply and bus cabling must be tested, especially the communication between setpoint sender and setpoint receiver.

Commissioning of VAV Compact Controllers consists of two parts:

- Commissioning of the VAV control function (cf. sections 6.1 and 6.2),
- Commissioning of the network integration.

Two basic workflows are supported:

- Full or partial configuration by a tool (bus configuration and optionally VAV configuration), usually AST20 or ACS941,
- Full or partial configuration over bus, optionally addressing by push-button.

7.3.2 Workflow 1: Full or partial configuration by tool

When using the AST20 handheld tool or the ACS941 PC tool, all bus parameters and VAV controller parameters (VAV control parameters and actuator parameters) can be set.

BACnet address and Max. Master setting

- Connect AST20 or ACS941 (using the AST11 interface converter) to the VAV controller and navigate to the bus configuration menu.
- Set bus parameters as desired, at least the address. Check Device Object ID and Max. Master as well: If Max. Master is lower than the desired BACnet address, the node will be identified as a “slave-only” device.
- Optionally make changes on VAV controller parameters in VAV configuration menu.
-

Note

- With AST20, all parameters can be set using the mass configuration function. The bus parameters are included in the mass programming routine. It can be selected that the address is automatically incremented with each programmed VAV controller. ACS941 supports saving and loading of parameter sets.

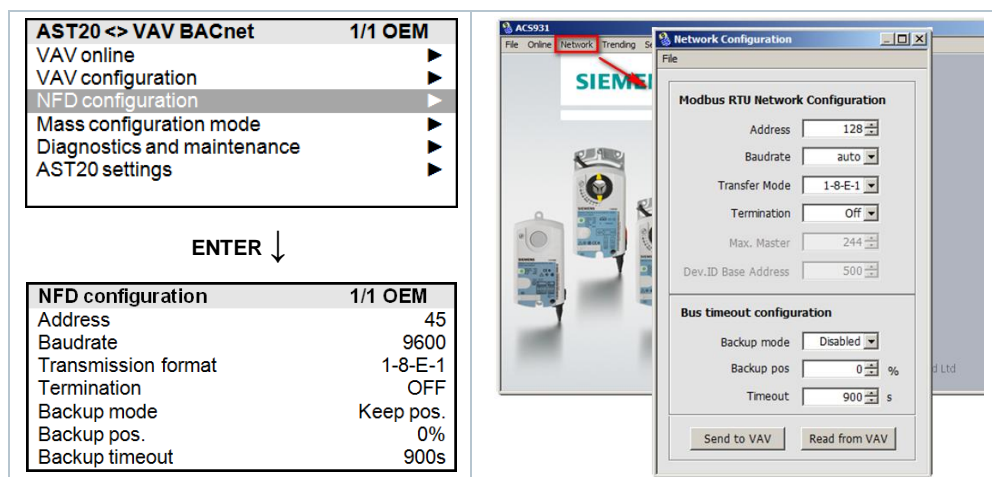


Figure 2: Bus configuration with AST20 (left) and with ACS941 (right)

7.3.3 Workflow 2: Full or partial onfiguration over bus

The devices can be configured over bus if the pre-commissioning settings allow for a connection between the configuration device (e.g. BACnet browser) and the peripheral devices (non-conflicting address and matching baudrate / transmission format).

- Full configuration over bus: If the address is unique per segment when powered up, the device can be accessed by the configuration tool and the address and other parameters can then be set to the definitive values.
- Partial configuration over bus: If the address is not unique per segment when powered up, each device must get a non-conflicting address before connecting it to the bus (e.g. using the push-button addressing method). After addressing all devices, the remaining configuration can be done over the bus using the default settings for baudrate (or auto-baud) and transmission mode.

Note

Overwriting the bus configuration over bus uses a timeout. If „1 = Load“ is not written into the BusConfigCommand (cf. 10.1.4) within 30 seconds, all values are discarded.

8 Safety and EMC optimization

8.1 Safety notes



This section contains general regulations and the regulations for mains and operating voltage. It also provides important information regarding your own safety and that of the entire plant.

Safety note

The warning triangle to the left means that observance of all relevant regulations and notes is mandatory. If ignored, injury to persons or damage to property may result.

General regulations

Observe the following regulations during engineering and project execution:

- Electrical and high-voltage directives of the respective country
- Other country-specific regulations
- House installation regulations of the respective country
- Regulations issued by the utility
- Diagrams, cable lists, disposition drawings, specifications and instructions as per the customer or the contractor in charge
- Third-party regulations issued by general contractors or building operators

Safety

The electrical safety of building automation and control systems supplied by Siemens depends primarily on the use of **extra low-voltage with safe isolation from mains voltage**.

SELV, PELV

Depending on the type of extra low-voltage earthing, a distinction is to be made between SELV and PELV as per HD 384, "Electrical plants in buildings":

Unearthed = SELV (Safety Extra Low Voltage)

Earthed = PELV (Protective Extra Low Voltage)

Earthing of G0 (system neutral)

Observe the following for grounding G0:

As a rule, earthing and non-earthing of G0 is permissible for AC 24 V operating voltage. Decisive are the local regulations and customary procedures. For functional reasons, earthing may be required or not permissible.

Recommendation on earthing G0

AC 24 V systems should always be earthed if this does not contradict the manufacturer's specification.

To avoid earth loops, systems with **PELV may only be earthed at one point of the system**, normally by the transformer, unless otherwise specified.

Operating voltage
AC 24 V

With regard to AC 24 V operating voltage, the following regulations must be complied with:

	Regulation
Operating voltage AC 24 V	The operating voltage must comply with the requirements for SELV or PELV: <ul style="list-style-type: none"> • Permissible deviation of AC 24 V nominal voltage at the actuators: +/-20 %
Specification on AC 24 V transformers	<ul style="list-style-type: none"> • Safety isolating transformers as per EN 61558, with double insulation, designed for 100 % on time to power SELV or PELV circuits • Determine the transformer's output by adding up the power consumption in VA of all actuators used • For efficiency reasons, the power drawn from the transformer should amount to at least 50 % of the nominal load • The transformer's nominal capacity must be at least 25 VA. With smaller transformers, the ratio of no-load voltage and full load voltage becomes unfavorable (> + 20 %)
Fusing of AC 24 V operating voltage	Secondary side of transformer: <ul style="list-style-type: none"> • According to the effective load of all connected devices • Line G (system potential) must always be fused • Where required, line G0 (system neutral) also

8.2 Device-specific regulations

 Device safety

Among other aspects, the safety of devices is ensured by extra low-voltage power supply (AC 24 V) as per **SELV** or **PELV**.

Electrical parallel connection

Electrical parallel connection of VAV Compact Controllers, provided the required operating voltage tolerance is observed. The **voltage drops of the supply lines** must be taken into consideration.

KNX bus powering

When planning and installing room controllers and field devices with KNX bus connection, the permissible cable lengths, power supply and topologies have to be followed. Planning should take into account possible future extensions of a plant.

Note



Warning,
maintenance

Mechanical coupling of the devices is not permitted.

Do not open the actuator!

The device is maintenance-free. Only the manufacturer may carry out any repair work.

8.3 Notes on EMC optimization

Running cable in a duct	Make sure to separate high-interference cables from equipment susceptible to interference.
Cable types	<ul style="list-style-type: none">• Cable causing interference: Motor cables, especially motors used with VSDs, energy cables• Cables susceptible to interference: Control cables, low-voltage cables, interface cables, LAN cables, digital and analog signal cables
Cable segregation	<ul style="list-style-type: none">• You can run both types of cable in the same duct, but in different compartments• If ducting with 3 closed sides and a partition is not available, separate the interference-emitting cables from other cables by a minimum of 150 mm, or route in separate ducting• Cross high-interference cables with equipment susceptible to interference only at right angles• If, in exceptional cases, signal and interference-emitting power cables are run in parallel, the risk of interference is high. In that case, limit the cable length of the DC 0...10 V positioning signal line for modulating actuators

9 Technical data

Power supply		
Operating voltage	G..B181.1E/..	AC 24 V \pm 20 % (SELV) or AC 24 V class 2 (US)
Frequency		50/60 Hz
Power consumption	at 50 Hz	
	Actuator holds	1 VA/0.5 W
	Actuator rotates	3 VA/2.5 W
Function data		
Positioning time for nominal rotation angle	G..B181.1E/..	150 s (50 Hz) 120 s (60 Hz)
Nominal torque	GDB..	5 Nm
	GLB..	10 Nm
Maximum torque	GDB..	< 7 Nm
	GLB..	< 14 Nm
Nom. / max. rotation angle		90° / 95° \pm 2°
Direction of rotation	Adjustable by tool or over bus	Clockwise / Counter-clockwise
Connection cables		
Cable length		0.9 m
Power supply	Number of cores and cross-sectional area	2 x 0.75 mm ²
Communication		3 x 0.75 mm ²
Service interface	Terminal strip	7-pin, grid 2.00 mm
Communication		
Communication protocol	BACnet MS/TP	RS-485, galv. separated
	Number of nodes	Max. 32
	Address range	0..128 (default: 1)
	Transmission format	1-8-N-1
	Max. master	1..127 (default: 127)
	Device object ID	0..4193404 (default: 10000)
	Baudrates (kBaud)	Auto / 9.6 / 19.2 / 38.4 / 57.6 / 76.8 / 115.2 (default: Auto)
	Termination	120 Ω electronically switchable (default: Off)
Degree of protection		
Degree of protection	Degree of protection acc. to EN 60529 (cf. mounting instr.)	IP54
Safety class	Safety class acc. to EN 60730	III
Environmental conditions		
Applicable standard		IEC 60721-3-x
Operation	Climatic conditions	Class 3K5
	Mounting location	Indoors
	Temperature general	0..50 °C
	Humidity (non condensing)	5...95 % r. h.
Transport	Climatic conditions	Class 2K3
	Temperature	-25...70 °C
	Humidity (non condensing)	5...95 % r. h.

Environmental conditions		
Storage	Climatic conditions	Class 1K3
	Temperature	-5...45 °C
	Humidity (non condensing)	5...95 % r. h.

Directives and Standards		
Product standard	EN60730-x	
Product family standard	EN 50491-3, EN 50491-5 General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS)	
Building automation and control systems (BACS) - Part 2 Hardware	EN ISO 16848-2	
Electromagnetic compatibility (Application)	For residential, commercial and industrial environments	
EU Conformity (CE)	GDB181.1E/BA	GLB181.1E/BA
	A5W00003842 ¹⁾	A5W00000176 ¹⁾
RCM Conformity	GDB181.1E/BA	GLB181.1E/BA
	A5W00003843 ¹⁾	A5W00000177 ¹⁾
UL, cUL	AC 24 V	UL 873 http://ul.com/database

Environmental compatibility
The product environmental declaration A6V10209938 ¹⁾ contains data on environmentally compatible product design and assessments (RoHS compliance, materials composition, packaging, environmental benefit, disposal).

Dimensions / Weight		
Weight	Without packaging	0.6 kg
Dimensions		71 x 158 x 61 mm
Suitable drive shafts	Round shaft (with centering element)	8...16 mm (8...10 mm)
	Square shaft	6...12.8 mm
	Min. drive shaft length	30 mm
	Max. shaft hardness	<300 HV

Air volume flow controller		
Type	3-position controller with hysteresis	
V _{max} , adjustable	resolution 1 %	20%...120% (factory setting: 100 %)
V _{min} , adjustable		-20%...100% (factory setting: 0 %)
V _n = f(dp _n), adjustable	resolution 0.01	1.00...3.16 (factory setting: 1.00)

Differential pressure sensor		
	Connection tubes (Interior diameter)	3...8 mm
	Measuring range	0...500 Pa
	Operating range	0...300 Pa
Precision at 23 °C, 966 mbar and optional mounting position	Zero point	± 0.2 Pa
	Amplitude	± 4.5 % of the measured value
	Drift	± 0.1 Pa / Year
	Max. permissible operating pressure	3000 Pa
	Max. permissible overload on one side	3000 Pa

¹⁾ The documents can be downloaded from <http://siemens.com/bt/download>

10 Datapoints and function description

10.1 BACnet Object List

10.1.1 Device object

ID	Obj. Type	Object Name	Property ID
Device ID (=0)	Device	Device	Object_Identifier
			Object_Name
			Model_Name
			Firmware_Revision
			Application_Software_Version
			Serial_Number
			Max_Master

10.1.2 Process values

ID	Obj. Type	Object Name	Property Name	Prop. ID	Range / Enum.	Default
0	AO	Setpoint	Setpoint	PV	0..100 %	
			LocalOverride	SF	1 = Off 2 = On	1
0	AI	ActualPosition	ActualPosition	PV	0..100%	
			ActPosCOV	CI	1%	5%
1	AI	ActualFlow Relative	ActualFlowRelative	PV	0..100%	
			ActFlowRelCOV	CI	1%	5%
2	AI	ActualFlow Absolute	ActualFlowAbsolute	PV	0..60'000 m ³ /h	
			ActFlowAbsCOV	CI	0.1 m ³ /h	10 m ³ /h
3	AI	ActualPressure	ActualPressure	PV	0..500 Pa	
			ActPressureCOV	CI	0.1 Pa	10 Pa
0	MSV	OverrideControl	OverrideControl	PV	1 = Off 2 = Open 3 = Close 4 = Stop 5 = GoToMin 6 = GoToMax	1

10.1.3 Parameters

ID	Obj. Type	Object Name	Property Name	Prop. ID	Range / Enum.	Default
1	MSV	ActCommand	ActCommand	PV	1 = Ready 2 = Adaption 3 = Selftest 4 = RelnitDevice 5 = RemoteReset	1
2	MSV	Direction	Direction	PV	1 = CW, 2 = CCW	1
3	MSV	OperatingMode	OperatingMode	PV	1 = VAV 4 = Pos	1
4	MSV	AdaptiveMode	AdaptiveMode	PV	1 = Absolute 2 = Adaptive	1
5	MSV	BackupMode	BackupMode	PV	1 = Backup Position 2 = Keep Still 3 = Disabled	1
0	AV	BackupPosition	BackupPosition	PV	0..100%	0%
0	PIV	BackupTimeout	BackupTimeout	PV	0..65535 s	900s
1	AV	MinPosition	MinPosition ¹⁾	PV	0..100%	0%
2	AV	MaxPosition	MaxPosition ¹⁾	PV	0..100%	100%
3	AV	VnValue	VnValue	PV	0.77..3.16	1.00
4	AV	Vnom	VnomAbsBox	PV	0..50'000 m ³ /h	100 m ³ /h
5	AV	VminScale	VminScale	PV	-20..100%	0%
6	AV	VmaxScale	VmaxScale	PV	0..120%	100%
1	PIV	AltitudeLevel	AltitudeLevel	PV	0..5000 m	500 m
2	PIV	RunTime Actuator	RunTimeActuator	PV	150 s	
6	MSV	UnitSwitch	UnitSwitch	PV	1 = m ³ /h 2 = l/s	1

¹⁾ rel. to adaption (AdaptiveMode)

10.1.4 Communication parameters

ID	Obj. Type	Object Name	Property Name	Prop. ID	Range / Enum.	Default
3	PIV	MSTP -Address	MacAddress	PV	0..128	1
4	PIV	DevObj-ID-Base	DevObjIdBase	PV	0..4'194'303	10'000
5	PIV	MaxMaster	MaxMaster	PV	1..127	127
7	MSV	Baudrate	Baudrate	PV / ST	1 = auto 2 = 9600 3 = 19200 4 = 38400 5 = 57600 6 = 76800 7 = 115200	1
0	BV	BusTermination	BusTermination	PV	0 = Off 1 = On	0
8	MSV	Bus Config. Command	BusConfig Command	PV	1 = Ready 2 = Load 3 = Discard	1

10.1.5 Status / statistics

ID	Obj. Type	Object Name	Property Name	Prop. ID	Resolution / Enumerations
0	BI	LocalOverride	LocalOverride	PV	1 = active 0 = inactive
1	BI	BackupMode Entered	BackupModeEntered	PV	1 = active 0 = inactive
2	BI	Device Jammed	DeviceJammed	PV	1 = active 0 = inactive
3	BI	NominalLife-timeExceeded	NominalLifetimeExceeded	PV	1 = active 0 = inactive
4	BI	Invalid Configuration	InvalidConfiguration	PV	1 = active 0 = inactive
0	MSI	Pressure SensorState	PressureSensorState	PV / ST	1 = No error 2 = Connection fault 3 = Comm. fault
1	MSI	SelftestStatus	SelfTestStatus	PV / ST	1 = Not tested 2 = Selftest failed 3 = Selftest passed
2	MSI	AdaptionState	AdaptionState	PV / ST	1 = Adaption not done 2 = Adaption done 3 = Adaption in progress 4 = Adaption error
6	PIV	Cumulated Uptime	CumulatedUpTime	PV	0..2 ³² s
7	PIV	Cumulated Running Time	CumulatedRunningTime	PV	0..2 ³² s
8	PIV	Counter Repositioning	CounterRepositioning	PV	0..2 ³² s
9	PIV	CounterPower Up	CounterPowerUp	PV	0..2 ³² s
10	PIV	CounterDevice Jam	CounterDeviceJam	PV	0..2 ³² s

Abbreviations:

BACnet Property ID	
PV	Present Value
SF	Status Flags
CI	COV Increment
ST	State Text

Object Type	
D	Device
MSI	MultiStateInput
MSV	MultiStateValue
PIV	PosIntValue
BI	BinaryInput
BV	BinaryValue
AI	AnalogInput
AO	AnalogOutput
AV	AnalogValue

10.2 Parameter and function description

10.2.1 Vnom (nominal volume flow) [m³/h or l/s]

VAV boxes are ordered through an OEM according to this nominal volume flow and min. / max. volume flow settings. The maximum volume flow for ventilating a room / zone can't be higher than the nominal volume flow. Often the maximum volume flow is lower than Vnom for potential future expansions of volume flows.

10.2.2 Vmin / Vmax (minimum / maximum volume flow) [%]

These values limit the nominal volume flow by multiplying with Vnom. Their effect is described in chapter 6.

10.2.3 Elevation above sea level [m]

This value enhances the accuracy of the differential pressure sensor to compensate for the air density decreasing with increasing altitude. It can be set in 500m steps, so for a given building the setting closest to the actual altitude is to be used.

Example: Altitude of building: 420m a.s.l. → use setting "500m"

10.2.4 Override control

The actuator can be operated in override control for checking / maintenance purposes or system-wide functions (e.g. night-cooling).

10.2.4.1 Local override:

The actuator enters this state when a service tool is connected at the service interface (PPS2).

- Open / Close (depends on opening direction)
- Stop
- If the actuator is in backup mode, it will be controllable in local override but resume the backup mode
 - when the service tool is disconnected ,
 - when the local override timeout is exceeded, or
 - when the override control is set to "off".
- Timeout is 10s after the last read or write access.

10.2.4.2 Remote override:

The actuator enters this state when an override command is sent over the bus. The override control is available as BACnet property with the following enumeration:

- Open / Close (depends on opening direction),
- GoToMin / GoToMax (depends on Min/Max settings and operating mode),
- Stop.

10.2.5 Adaptive positioning

For VAV boxes and air dampers where the opening range is smaller than the nominal opening range 0..90°, the position feedback signals can be adapted to have the actual opening range represented as 0..100%.

- Adaptive positioning off: Any position is commanded and reported relative to the absolute 0° base, e.g. 0° → 0%, 18° → 20%, 81° → 90% etc.
- Adaptive positioning on: Any position is commanded and reported relative to the actual minimum and maximum position.

Example A: The minimum position is 24° and the maximum position is 90°

→ the absolute position 24° is commanded and reported as 0%

→ the absolute position 43° is commanded and reported as 29%.

Example B: The minimum position is 24° and the maximum position is 60°

→ the absolute position 24° is commanded and reported as 0%.

→ the absolute position 43° is commanded and reported as 53% = $(43° - 24°) / (60° - 24°)$.

- Using adaptive positioning makes the actuator driving to its end positions at the first startup after activating the adaptive positioning.
- To trigger the adaptation again after the first startup, use either the actuator command "Adaption", or the adaptive positioning can be turned off and on again.

10.2.6 Operating mode

The operating mode determines whether the setpoint signal (0..100 %) from the supervisory controller is interpreted as volume flow control or as (air damper) position control.

If used as damper control signal, the actual/feedback values from the flow sensor remain available, e.g. to implement the flow control loop in an external controller.

10.2.7 Backup mode

In case the communication to the controller is lost, the device can be configured to go into a defined state. This function utilizes a watchdog which monitors setpoint write access over the bus.

Default setting of this backup mode is "Off", i.e. in case of a communication loss, the device controls to the last received setpoint until an updated setpoint is received.

If the backup mode is enabled, it can be configured as follows:

- go to a position predefined by the parameter "Backup position",
- keep current position without controlling to the last received setpoint.

When the device is in backup mode and receives a setpoint over the bus again, it wakes up and controls to the setpoint again.

10.2.8 Restarting the device

Restarting is possible by:

- Power-reset (turning operating voltage off and on) or
- by “ReInitDevice” command.

Effect of restart: Device re-initializes and sets all process values to defaults.

10.2.9 Reset behavior

The actuator supports the following re-initialization / reset behavior:

- Local reset by push-button: cf. section **2.4.2**
- Tool-reset, cf. section **6.2**
- Remote reset: Using “RemoteFactoryReset” command.

Effect of reset:

- Process values: set to ex-works default values.
- Parameters:
 - Application and actuator parameters are set to factory or OEM defaults,
 - Network parameters are reset only in case of local reset, not by remote reset (otherwise loss of communication).
- Counters are not reset.
- Status flags are not reset.
- Device Information and Factory Data are not reset.

10.2.10 Selftest

The actuator supports a selftest. When triggered, the selftest runs the actuator to the detected limits and sets the flags according to the result (cf. properties “Actuator Command” and “Selftest Status”).

- The selftest is not passed when the limits were not reached from the lower end (results in device jam).
- If the limits can be exceeded, the selftest is not evaluated as failed.

10.2.11 Configuration check

The actuator supports a basic configuration check for the relation between Vmin and Vmax: Vmax must be greater than Vmin, otherwise this is regarded as an invalid configuration. Tolerance level is 2% difference.

In case of an invalid configuration, the LED blinks red and the flag “invalid configuration” in the according BACnet property (cf. **10.1.5**) is set to “1”.

11 Environmental compatibility and disposal

General notes

The products were developed and manufactured by using environmentally compatible materials and by complying with environmental standards. For disposal, please remember the following at the end of product life or in case of defects:

- The products consist of plastics and materials such as steel, ferrite magnetic core, etc. and must not be disposed of together with domestic waste; this applies particularly to the printed circuit boards.
See also European Directive 2012/19/EU
- As a rule, dispose of all waste in an environmentally compatible manner and in accordance with the latest developments in environmental, recycling and disposal techniques.
Local and currently valid legislation must be observed.
- The aim is to achieve maximum recyclability of the basic materials while ensuring minimum strain on the environment. To do this, note the various material and disposal notes printed on specific components

Environmental declaration

The Environmental Declarations on these products contain detailed information about the materials and volumes used.

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