SIEMENS

Modbus RTU

OpenAir™
VAV Compact Controller Modbus RTU
G..B181.1E/MO

Technical Basics

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1 Introduction

1.1 Revision history

Version	Date	Changes	Section	Pages
d	2019-09-13	AST22 replaces AST11	2 Device	6
c	2018-04-16	LED colors and patters updated, internal diagrams	2 Device	10 12
b	2016-02-26	EU and RCM Conformity, European Directive 2012/19/EU	9 Technical data, 11 Environmental compatibility and disposal	32 38
a	2015-07-20			

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1.3 Objectives of this basic documentation

This basic documentation covers the networked VAV Compact Controllers G..B181.1E/MO. 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/MO - VAV Compact Controllers Modbus RTU - Datasheet (A6V10631832)

[2] Mounting instruction for VAV Compact Controllers (A6V10523083)

[3] AST20 - Handheld tool for VAV compact controller - Datasheet (A6V10631836)

[4] AST20 - Handheld tool for VAV Compact Controller - Manual (A6V10555077)

[5] AST22 - Interface converter (A6V11236956)

[6] ACS931 - PC-Software for OEM - Datasheet (N5853)

[7] ACS941 - PC-Software for Service - Datasheet (N5854)

[8] Modbus over serial line - Specification and Implementation Guide (www.modbus.org)

2 Device

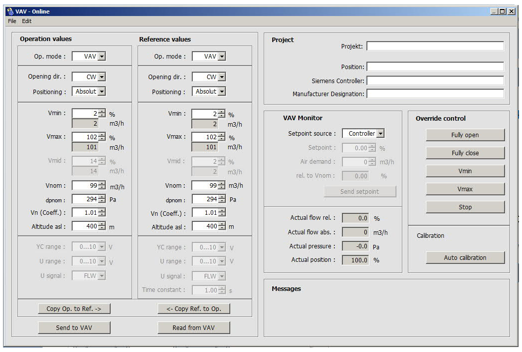
2.1 Type summary

2.1.1 Device variants, tools and accessories

VAV Compact Controller Modbus RTU

GDB181.1E/MO (5 Nm)	GLB181.1E/MO (10 Nm)
	

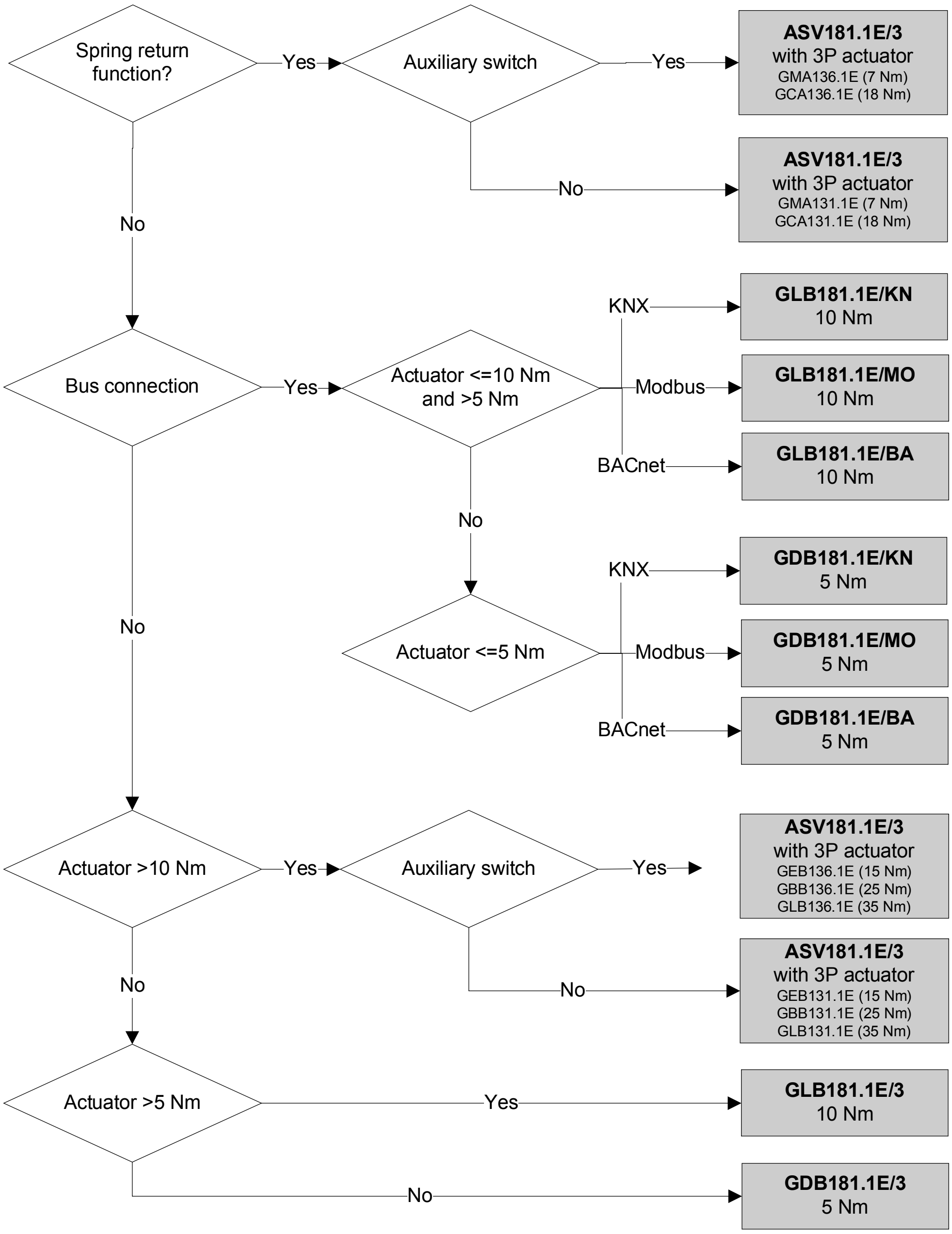
Tools for commissioning and service

AST20	ACS931 / ACS941
	
The handheld tool AST20 can be used for status monitoring, VAV parameter setting, and bus configuration setting.	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 AST22 is required.
Datasheet: A6V10631836 Instructions: A6V10555077	Datasheet ACS941: N5854 Datasheet AST22: A6V11236956

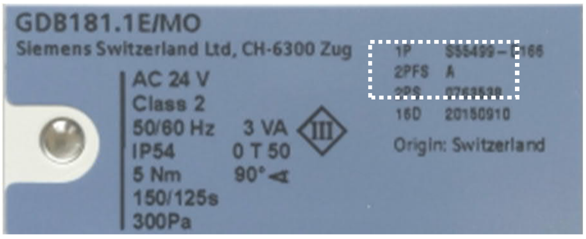
Accessories

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	
Features	▪ 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.

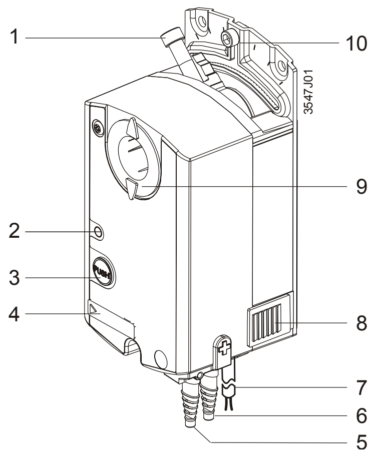
Components contained in the **base**:

- 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

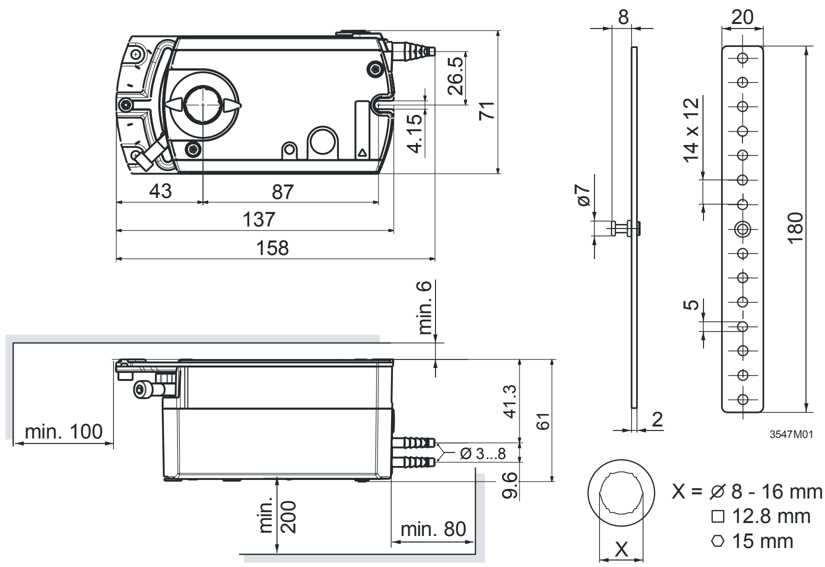


1 Shaft attachment screw
2 LED
3 Push button
4 Configuration and maintenance interface (below cover)
5 Connection nozzle for measuring differential pressure in the VAV box
6 Connection nozzle for measuring differential pressure in the VAV box ("+": Side with higher pressure)
7 Two connecting cables (power and communications), 2-core each
8 Disengagement of gear train
9 Rotation angle display
10 Rotation angle check screw

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



Measures in mm

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")
	flashing	Bus traffic
Orange	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** 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

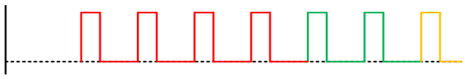
When using the AST20 handheld tool or the ACS941 PC tool, all bus parameters as well as most VAV controller parameters (VAV control parameters and actuator parameters) can be set.

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 button[1].
   - 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

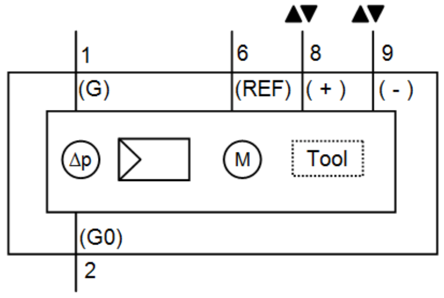
Set address “5”:
1. Enter addressing mode
2. Set 1-digits: Press button 5-times → LED flashes **green** per button press
3. Store address: press button until LED shines **red**
   → address is stored and displayed 1x for confirmation

[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.

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 (Modbus RTU)
9	pink (PK)	-	Bus (Modbus RTU)

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.

- 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.

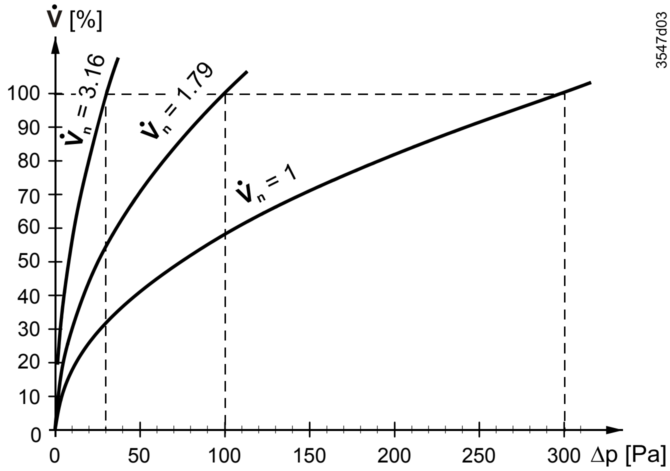
Note

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

Setting the characteristic value Vn

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 Vn



Calculation of Vn
(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 Δp_n = 120 Pa. Then, V_n has to be set to 1.58:

$$\dot{V}_n = \sqrt{\frac{300\ \text{Pa}}{120\ \text{Pa}}} = \sqrt{2.5} = 1.58$$

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 Modbus RTU (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 Controllers with Modbus 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 Modbus configuration may not be shown.

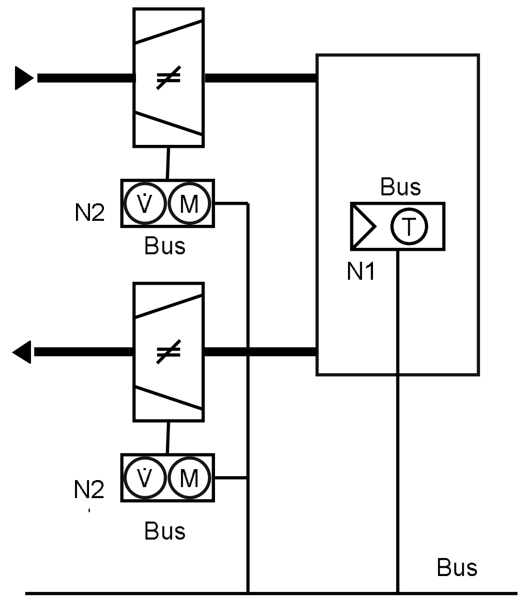
Control of air volume flow in supervisory controller

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)

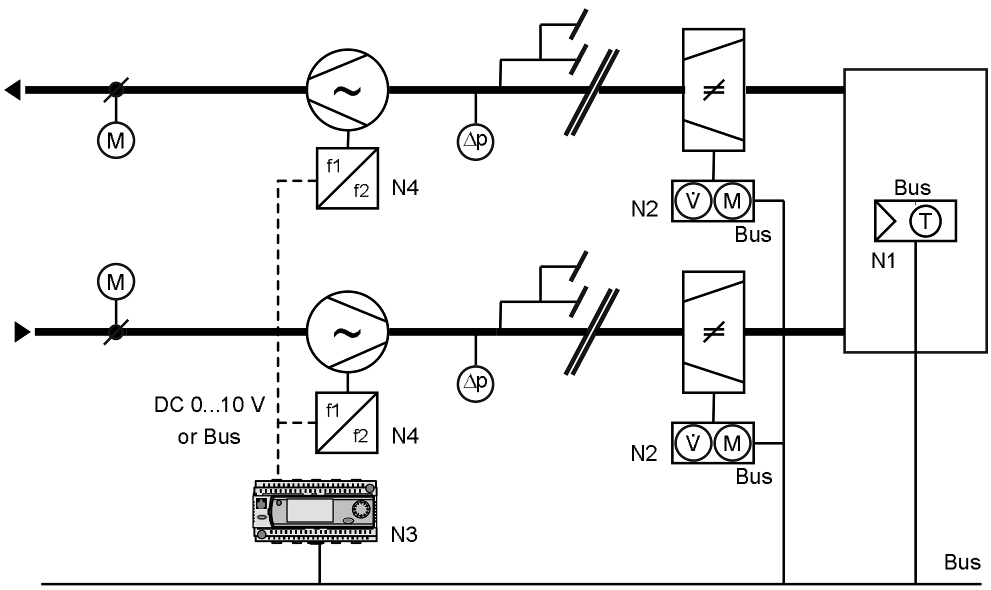
When omitting the extract air part, a simple supply air control application can be realized. Disadvantages are that ventilation conditions in the room or zone can't be controlled precisely.

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 Modbus-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 [2] is mandatory.

Environmental conditions

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

Manual control

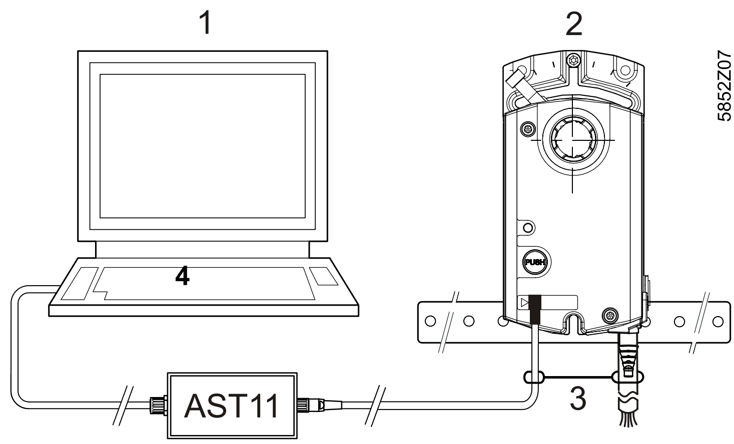
The actuator may only be manually operated when **separated from power supply**.

Mechanical limitation of angular rotation

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

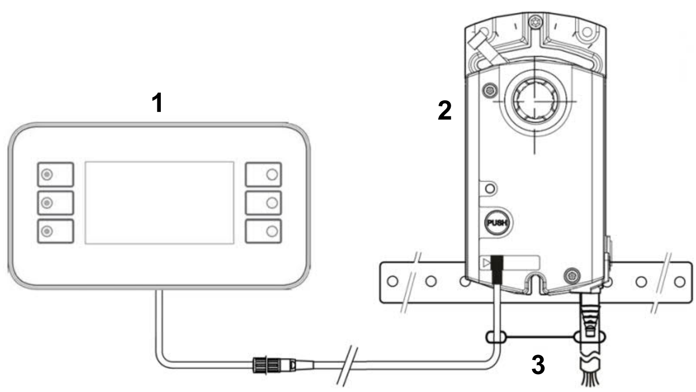
Configuration and maintenance interface

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



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

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



1 AST20
2 G..B181.1E/MO
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:

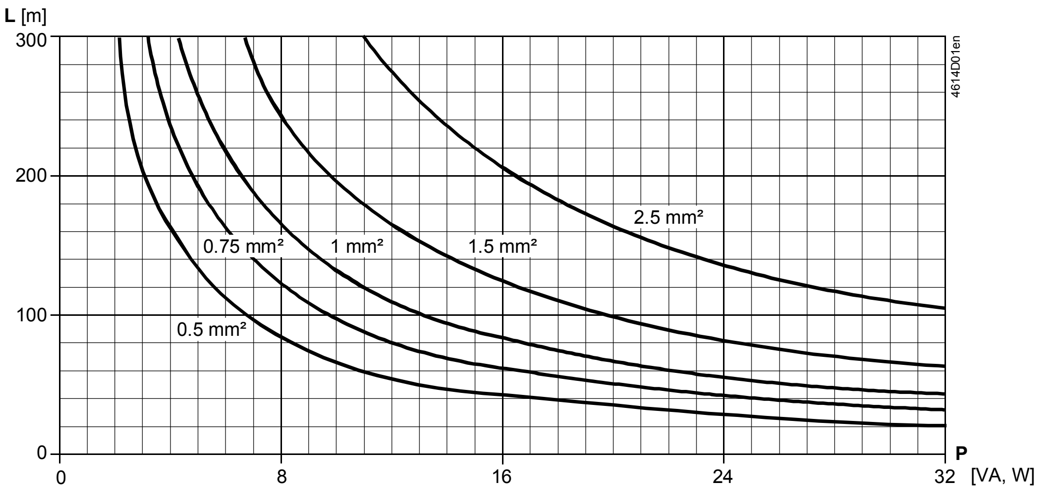
Type	Operating Voltage	Line	Max. permissible voltage drop
GDB181.. / GLB181..	AC 24 V	G0, G	System voltage AC 24 V

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.

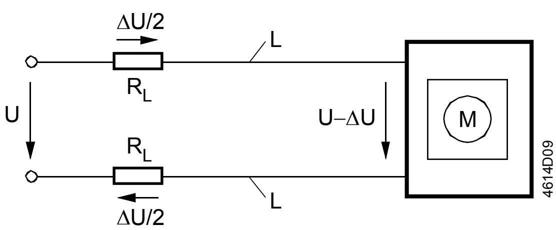


Note on chart

The values in [VA, W] on the P-abscissa are allocated to the permissible voltage drops (ΔU/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	$L = \frac{1313 \bullet A}{P}$ [m]

A Cross-sectional area in [mm^2]
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 mm^2
- 274 m with a cross-sectional area of 2.5 mm^2

5.2.2 Bus cabling

Instructions regarding topology and addressing in Modbus RTU networks can be found in [8]. 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.

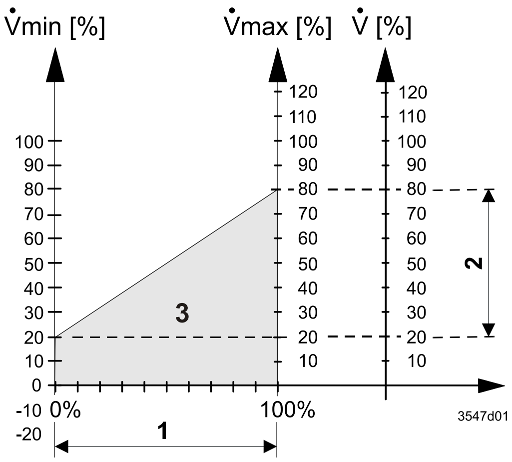
For parameter setting, configuration and maintenance tools as described in section **6.2** are available. The following parameters must be checked or set prior to commissioning. Settings and changes have to be documented in the plant documentation.

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°...90° → 0..100 % On = Pos. adaption / mapping e.g. 0°...60° → 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 to section **10.2** for more explanation.			

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

Variable air volume control (VAV)

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



1 Setpoint
2 Actual value
3 Control range

Constant air volume control (CAV)

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 Vn (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

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

Differential pressure as function of actual value

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

6.2 Configuration and maintenance tools

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

- Using the PC software ACS941or ACS931 together with the interface converter AST22 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 ([7]).

The PC software ACS941 allows to set or to display the parameters as listed in section **6.1**. The software supports trend functions and allows comparing the values set by the OEM with the values currently stored in the device. Thus, changes by parties other than the OEM can be detected.

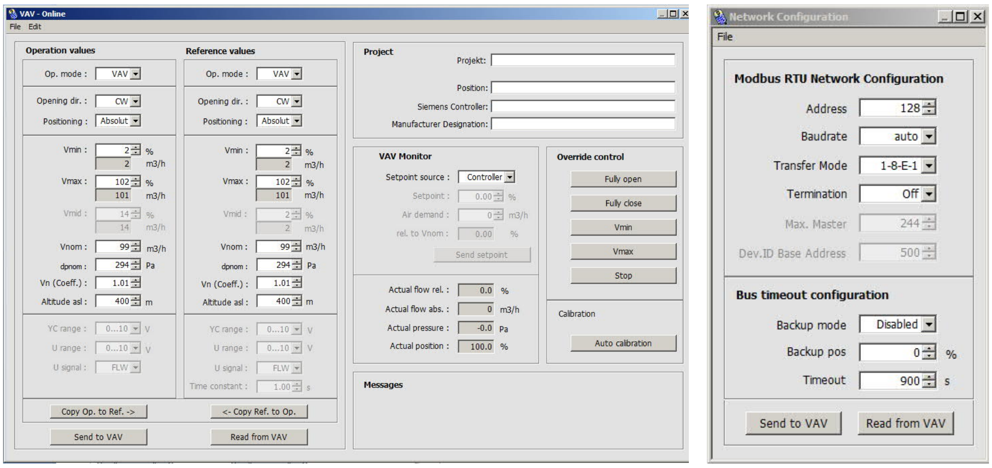


Figure 1: ACS941 with VAV (left) and network (right) configuration pane

Next to the PC software ACS941, an OEM version ACS931 ([6]) with extended functionality is available as well. ACS931 allows setting the parameter V_n.

6.2.2 Handheld tool AST20

Functionality

Using the handheld tool AST20, VAV and Modbus RTU parameters can be set or retrieved. Instructions for use of the handheld tool AST20 can be found in data sheet [3] and in the manual [4].

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 [%]
$\dot{V}_{supply\_ air}$	Volume flow of supply air controller [%]
$\dot{V}_{extract\_ air}$	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

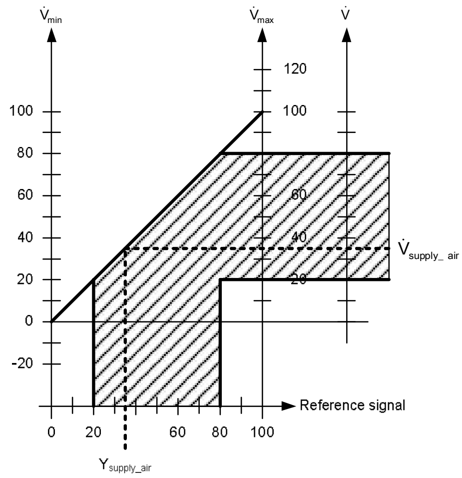
VAV ratio control 1 : 1

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

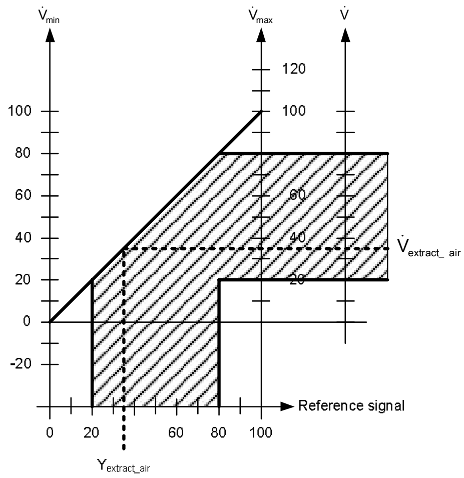
Reference signal: $Y_{supply\_air} = Y_{extract\_air}$ = 35 %

Result: $V_{supply\_air} = V_{extract\_air}$ = 35 %

Supply air controller



Extract air controller



Setting example A2

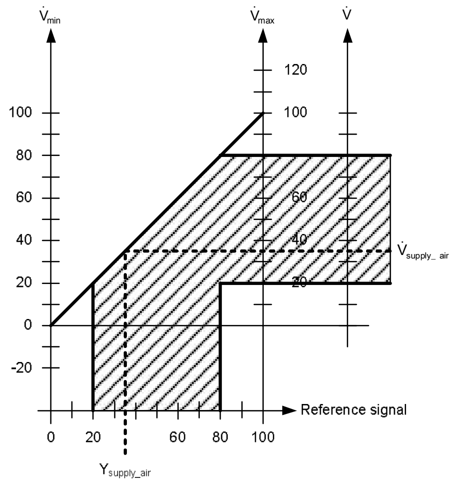
VAV ratio control, 20 % constant excess supply air volume flow (positive pressure in the room)

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

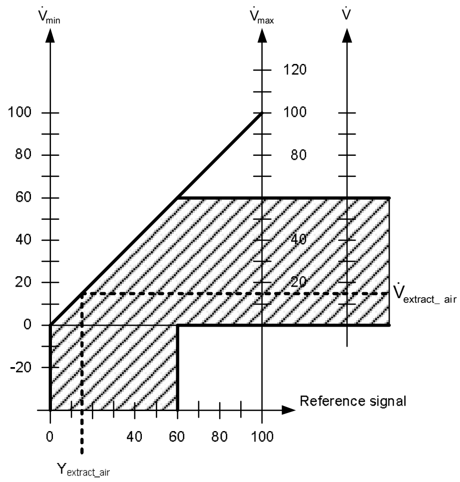
Reference signal: Y_{supply_air} = 35 %, $Y_{extract\_air} = Y_{supply\_air}$ - 20 % = 15 %

Result: V_{supply_air} = 35 %, $V_{extract\_air}$ = 15 %

Supply air controller



Extract air controller



Setting example A3

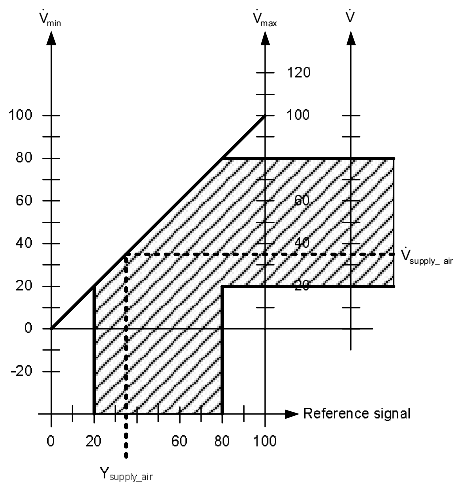
VAV ratio control, 20 % constant excess extract air volume flow (negative pressure in the room)

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

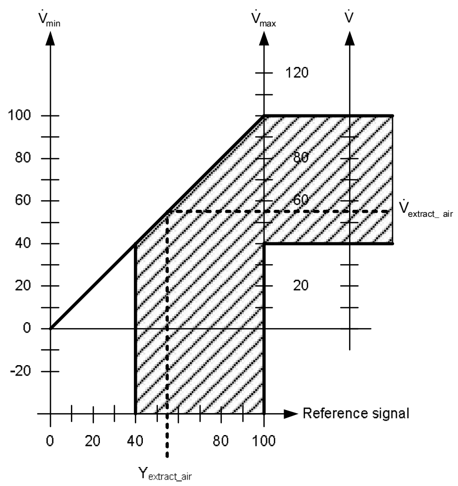
Reference signal: Y_{supply_air} = 35 %, $Y_{extract\_air} = Y_{supply\_air}$ + 20 % = 55 %

Result: V_{supply_air} = 35 %, $V_{extract\_air}$ = 55 %

Supply air controller



Extract air controller



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.

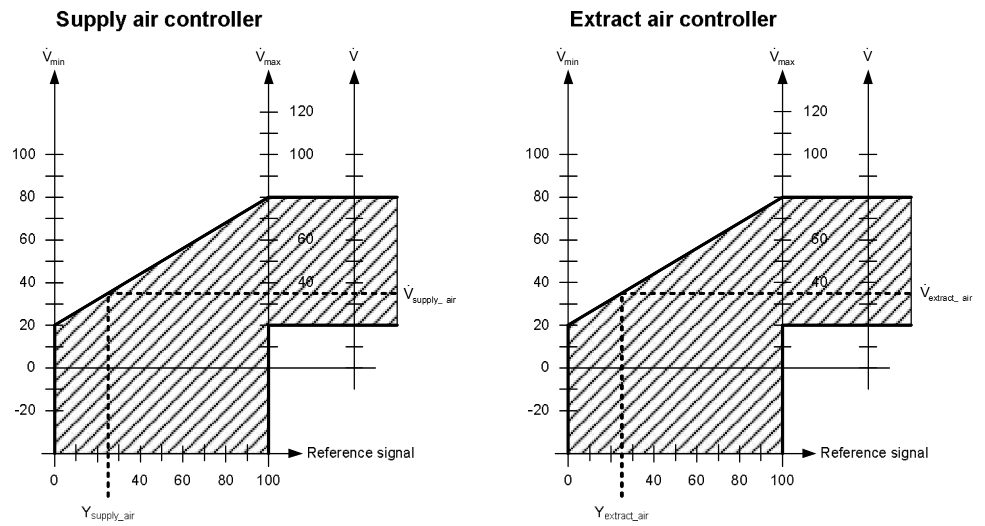
Setting example B1

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: $Y_{supply\_air} = Y_{extract\_air} = 25$ %

Result: $V_{supply\_air} = V_{extract\_air} = 35$ %



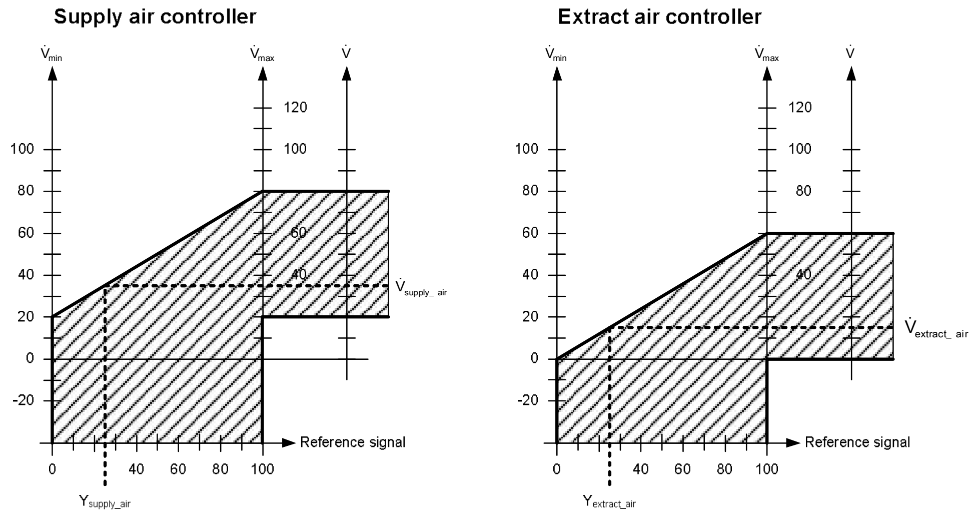
Setting example B2

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: $Y_{supply\_air} = Y_{extract\_air} = 25$ %

Result: $V_{supply\_air} = 35$ %, $V_{extract\_air} = 15$ %



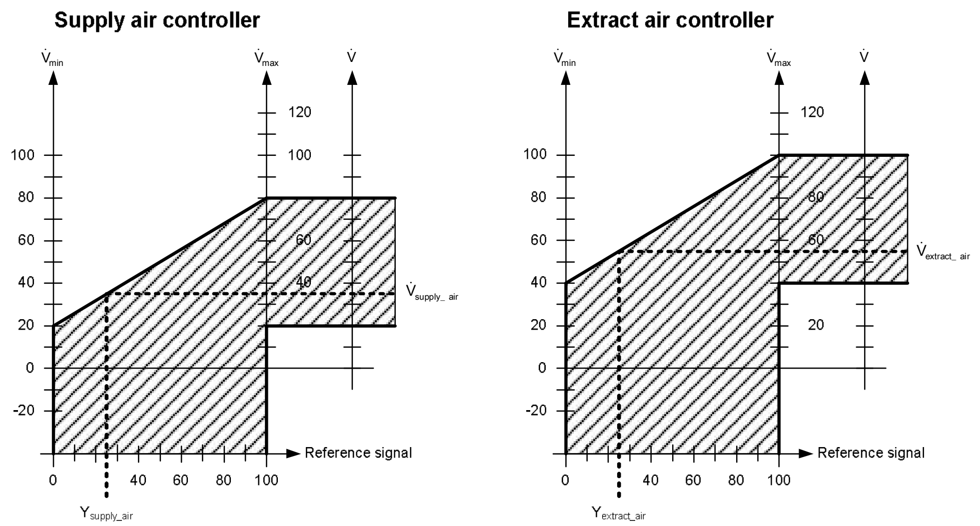
Setting example B3

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: $Y_{supply\_air} = Y_{extract\_air} = 25$ %

Result: $V_{supply\_air} = 35$ %, $V_{supply\_air} = 55$ %



7 Engineering and commissioning

7.1 Fundamentals / environments

Preconditions

For this chapter, sufficient knowledge about Modbus RTU communication and suitable controllers are presupposed.

7.2 Engineering

The basic task of engineering comprises implementation of the data model into a VAV application, especially setpoint and actual values (flow and position) for monitoring and optimization. System limitations of Modbus RTU / RS-485 apply, especially number of devices per segment and cable lengths depending on the baudrate.

The data model is documented as Modbus register list, cf. **10.1** .

7.3 Commissioning

7.3.1 Preconditions

Commissioning preconditions

The beginning of the commissioning phase assumes that all VAV Compact Controllers are mounted according to the mounting instruction [2] 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 (bus configuration and optionally VAVconfiguration) by a tool (AST20 or ACS941),
- Full or partial configuration over bus, optionally with 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 Compact Controller parameters can be set.

- Connect AST20 or ACS941 (using the AST22 interface converter) to the VAV controller and navigate to the bus configuration menu,
- Set bus parameters as desired,
- 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.

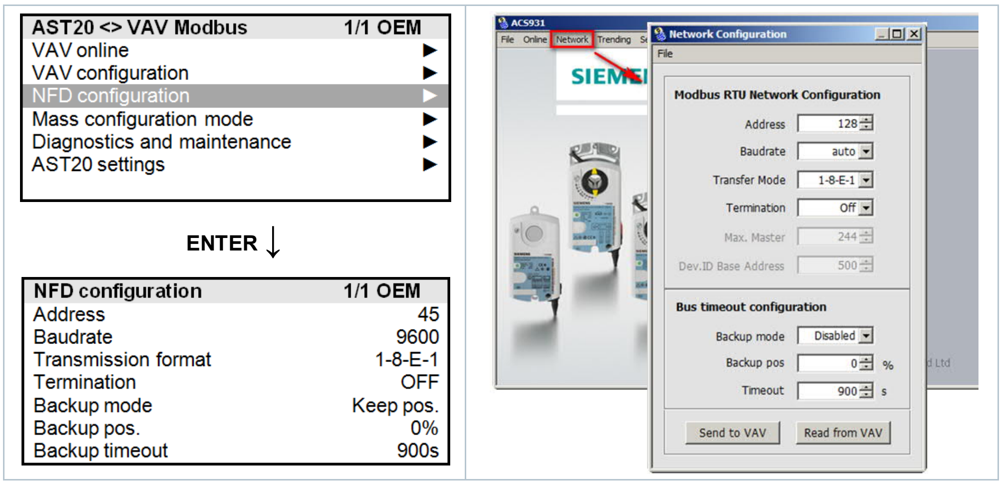


Figure 2: Bus configuration with AST20 (left) and with ACS941 (right)

7.3.3 Workflow 2: Full or partial configuration over bus

The devices can be configured over bus if the pre-commissioning settings allow for a connection between the Modbus master (or programming tool) and 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 Modbus master (or programming 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 for the Modbus master.
- Overwriting the bus configuration over bus uses a timeout. If „1 = Load“ is not written into Reg 768 within 30 seconds, all values are discarded.

Example

The following table shows bus configuration registers before and after changing them over bus. Attention is to be paid to register 768.

Reg.	Name	Pre-commissioning	New value (ex.)
764	Address	46	12
765	Baudrate	0 = auto	1 = 9600
766	Transmission Mode	0 = 1-8-E-1	3 = 1-8-N-2
767	Termination	0 = Off	0 = Off
768	BusConfigCmd	0 = Ready	1 = Load

8 Safety and EMC optimization

8.1 Safety notes

STOP

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** (**S**afety **E**xtra **L**ow Voltage)
Earthed = **PELV** (**P**rotective **E**xtra **L**ow **V**oltage)

⚠ 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: • Permissible deviation of AC 24 V nominal voltage at the actuators: +/–20 %
Specification on AC 24 V transformers	• 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: • 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

Mechanical coupling of the devices is not permitted.

Warning, maintenance

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

- 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

- 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 ± 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° ± 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		
Connection type	Modbus RTU	RS-485, galv. separated
	Number of nodes	Max. 32
	Address range	1..255 (default: 255)
	Transmission formats	1-8-E-1 / 1-8-O-1 / 1-8-N-1 / 1-8-N-2 (default: 1-8-E-1)
	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 (see mounting instruction)	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	5...95 % r. h.

Environmental conditions			
Storage	Climatic conditions	Class 1K3	
	Temperature	-5…45 °C	
	Humidity	5...95 % r. h.	

Directives and Standards			
Product standard		EN 60730-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)	
Electromagnetic compatibility (Application)		For residential, commercial and industrial environments	
EU Conformity (CE)		GDB181.1E/MO	GLB181.1E/MO
		A5W00003842 [1)]	A5W00000176 [1)]
RCM Conformity		GDB181.1E/MO	GLB181.1E/MO
		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	
Vmax, adjustable	resolution 1 %	20%...120% (factory setting: 100 %)
Vmin, 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 Modbus Registers

For detailed descriptions of the function behind a certain item, e.g. “how does RemoteFactoryReset in register 256 work”, please cf. section **10.2**.

Reg.	Name	R/W	Unit	Scaling	Range / enumeration
Process Values					
1	Setpoint	RW	%	0.01	0..100
2	Override control	RW	--	--	0 = Off / 1 = Open / 2 = Close 3 = Stop / 4 = GoToMin 5 = GoToMax
3	Actual position	R	%	0.01	0..100
4	Actual Flow [rel.]	R	%	0.01	0..120
5	Actual Flow [abs.]	R	m^3/h / l/s	1	0..60000
6	Actual Pressure	R	Pa	0.1	0..500
256	Command	RW	--		0 = Ready 1 = CalibrateAdaption 2 = SelfTest 3 = ReInitDevice 4 = RemoteFactoryReset

Reg.	Name	R/W	Unit	Scaling	Range / enumeration
Parameters					
257	Opening direction	RW	--	--	0 = CW / 1 = CCW
258	Adaptive Mode	RW	--	--	0 = Off / 1 = On
259	Operating Mode	RW	--	--	0 = VAV / 1 = POS
260	MinPosition	RW	%	0.01	0..100
261	MaxPosition	RW	%	0.01	0..100
262	Actuator Running Time	R	s	1	150
385	Vnom	RW	m3/h	0.0001	0…429496.7295
386	Vmin	RW	%	0.01	-20..100
387	Vmax	RW	%	0.01	0..120
388	Altitude Level	RW	m	1	0..5000
389	Unit Switch	RW	--	--	0 = m3/h 1 = l/s
513	Backup Mode	RW	--	--	0 = Go to BackupPosition 1 = Keep last position 2 = Disabled
514	Backup Position	RW	%	0.01	0..100
515	Backup Timeout	RW	s	1	0..65535
764	Modbus Address	RW	--	--	1..247 / 255 = “unassigned”
765	Baudrate	RW	--	--	0 = auto / 1 = 9600 / 2 = 19200 3 = 38400 / 4 = 57600 / 5 = 76800 6 = 115200
766	Transmission Format	RW	--	--	0 = 1-8-E-1 / 1 = 1-8-O-1 2 = 1-8-N-1 / 3 = 1-8-N-2
767	Bus Termination	RW	--	--	0 = Off / 1 = On
768	Bus Conf. Command		--	--	0 = Ready / 1 = Load / 2 = Discard
769	Status	R	--	--	See below

<table>
<tr><th>Reg.</th><th>Name</th><th>R/W</th><th>Value</th><th>Example</th></tr>
<tr><td colspan="5">Device information</td></tr>
<tr><td>1281</td><td>Factory Index</td><td>R</td><td>Two bytes, each coding an ASCII char.</td><td>00 5A → 00 “Z”
Device is of Series “Z”</td></tr>
<tr><td>1282</td><td>Factory Date HWord</td><td>R</td><td>Two bytes, the lower coding the Year (hex)</td><td rowspan="2">Read 1282 → 000F
Read 1283 → 0418<table><tr><th></th><th colspan="2">HWord</th><th colspan="2">LWord</th></tr><tr><td></td><td>--</td><td>YY</td><td>MM</td><td>DD</td></tr><tr><td>Hex</td><td>00</td><td>0F</td><td>04</td><td>18</td></tr><tr><td>Dec</td><td>00</td><td>15</td><td>04</td><td>24</td></tr></table>→ Device was manufactured 24 April, 2015</td></tr>
<tr><td>1283</td><td>Factory Date LWord</td><td>R</td><td>High byte: coding the month (hex)
Low byte: coding the day (hex)</td></tr>
<tr><td>1284</td><td>Factory SeqNo HWord</td><td>R</td><td rowspan="2">Hword + LWord = HEX-representation of Sequence number:</td><td rowspan="2">Read 1284 → 000A
Read 1285 → A206
AA206(hex) → 696838 (dec)
→ Device has sequence number 696838</td></tr>
<tr><td>1285</td><td>Factory SeqNo HWord</td><td>R</td></tr>
<tr><td>1409</td><td>TypeASN [Char_16..1]</td><td>R</td><td rowspan="6">Each register: Two bytes, each coding an ASCII char.
ASN is coded beginning with reg. 1409</td><td rowspan="6">Example:
0x47 44 = GD
0x42 31 = B1
0x38 31 = 81
0x2E 31 = .1
0x45 2F = E/
0x4D 4F= MO
→ ASN is GDB181.1E/MO</td></tr>
<tr><td>1410</td><td>TypeASN</td><td></td></tr>
<tr><td>1411</td><td>TypeASN</td><td></td></tr>
<tr><td>1412</td><td>TypeASN</td><td></td></tr>
<tr><td>1413</td><td>TypeASN</td><td></td></tr>
<tr><td>1414</td><td>TypeASN</td><td></td></tr>
</table>

Register “Status”

The status register indicates the True/False state of the listed items.

Status			
Bit 00	1 = Local override	Bit 06	1 = CalibrateAdaptionDone
Bit 01	1 = Backup mode active	Bit 07	1 = Calibration in progress
Bit 02	1 = Sensor comm. fault	Bit 08	1 = Calibration error
Bit 03	1 = Sensor tubes crossed	Bit 09	1 = Selftest failed
Bit 04	1 = Device jammed	Bit 10	1 = Selftest passed
Bit 05	1 = Nom. lifetime exceeded	Bit 11	1 = Invalid configuration

Supported function codes

The following function codes are supported. For function code 16 “Write multiple register”, the limitation of max. 120 register within one message applies..

Function codes	
03 (0x03)	Read Holding Registers
04 (0x04)	Read Input Registers
06 (0x06)	Write Single Register
16 (0x10)	Write Multiple registers

10.2 Parameter and function description

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

→ *Register 385*

VAV boxes are ordered through an OEM according to the required nominal volume flow (Vnom) and min. / max. volume flow settings (Vmin / Vmax). The maximum volume flow for ventilating a room / zone can't be higher than the nominal volume flow.

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

→ *Registers 386/387*

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]

→ *Register 388*

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

→ *Register 2*

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 by the service interface (PPS2). Available commands:

- Open / Close (depends on opening direction)
- GoToMin / GoToMax (depends on Min/Max settings)
- 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 in Modbus register 2 with the following enumeration:

- Open / Close (depends on opening direction)
- GoToMin / GoToMax (depends on Min/Max settings)
- Stop

10.2.5 Adaptive positioning

→ *Register 258*

For VAV boxes and air dampers where the opening range is smaller than the nominal opening range 0...90°, the 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, either the command "CalibrateAdaption" (Write "1" into register no. 256), or the adaptive positioning can be turned off and on again.
-

10.2.6 Operating mode

→ *Register 259*

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 values from the flow sensor remain available, e.g. to implement the flow control loop in an external controller.

10.2.7 Backup mode

→ *Registers 513, 514, 515*

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 disabled, i.e. in case of a communication loss, the device controls indefinitely to the last received setpoint.

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 performs control to the setpoint again.

10.2.8 Restarting the device

→ Register 256

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

→ Register 256

The actuator supports a selftest. When triggered, the selftest runs the actuator to the detected limits and sets the flags in register 769 according to the result (bit 09 = 1→"failed" or bit 10 = 1 → "passed").

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

10.2.11 Configuration check

→ Register 769

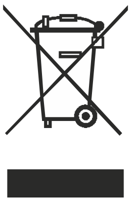
The actuator supports a basic configuration check for the relation between Vmin and Vmax: Vmax must be greater then Vmin, otherwise this is regarded an invalid configuration. Tolerance level is 2% difference.

In case of an invalid configuration, the LED blinks red and the flag "invalid configuration" in the status register (bit 11 in reg. 769) 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. If you need a copy, please contact your Siemens sales office.

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