Control engineering information

VARYCONTROL VAV Units
VAV Compact flow rate controller

BC0 · BF0

TROX® TECHNIK
The art of handling air

Contents

TROX® TECHNIK

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1 General information

Correct use

The VAV Compact electronic controller is part of the air terminal unit and provides a control loop for flow rate control. The controller is delivered ready to operate. Parameters are factory set.

The air terminal units are suitable for use in ventilation and air conditioning systems. Particular conditions can restrict the functional capacity and must be taken into account during the design stage:

- Installation should only be carried out by specialists. The normal local rules of site working, in particular the health and safety regulations must be complied with.
- For air with aggressive media, only air terminal units made of plastic materials should be used and then only after extensive tests for suitability.
- Galvanised sheet steel units must not be installed in contaminated environments (e.g. acetic acid).

For the VAV Compact electronic controller the following must be noted:

- Use in aircraft is not allowed.
- Safety transformers must be used.
- The user should not exchange or repair any parts of the controller.
- The controller consists of electronic components therefore must be separated from domestic waste. When disposed of, local up to date regulations must be complied with.
- For hazardous areas, only use units with explosion proof electrical components.
- If there is a risk of fire due to flammable solids, the electric equipment must be rated IP 4X (see VdS 2033 fire safety guidelines or appropriate regulations).

Standard filtration in air conditioning systems is suitable for the use of the VAV Compact in the supply air without additional dust protection filters.
Since only a small volume flow is passed through the transducer in order to monitor the flow rate, the following must be noted:

- With heavy dust in the room, suitable extract air filters must be provided.
- If the air is contaminated with fluff or sticky particles or contains aggressive media, the VAV Compact should not be used.

Materials

Please note that in critical cases, material compatibility testing must be carried out on the air terminal unit and the transducer, taking into consideration the harmful substances involved and the concentrations in which they occur.

Maintenance

- The mechanical components are maintenance-free

2 Field of application, Technical data

Field of application

The VAV Compact is designed for use in VAV systems for flow rate control.

A dynamic differential pressure transducer, damper actuator and electronic controller are combined in one casing . The variable control input is used for the control requirements. For variable control, a signal is provided by, for example, a room temperature controller, an air quality controller, a set point adjuster or a DDC outstation. The control signal is an electrical signal.

For constant control switches or relays are used for three adjustable setpoints. The actual value of the flow rate is monitored as a standard linear, electrical signal. Control signals can be in two ranges:

- 0 to 10 V DC (Standard)
- 2 to 10 V DC

Using the adjustment tool ZTH-VAV, the customer can change the voltage range.

The flow rate is microprocessor-controlled on a digital basis. The VAV Compact has no potentiometer or switches, because all the parameters, including $\dot{V}_{min}$ and $\dot{V}_{max}$, are stored in memory.

The controller is supplied with all the parameters set. The flow rate can be changed by the customer easily and reliably using an adjustment tool ZTH-VAV or a notebook with service tool and certain parameters are read only.

Several controllers may be connected in parallel to one room temperature controller.

Supply - extract tracking control is possible.

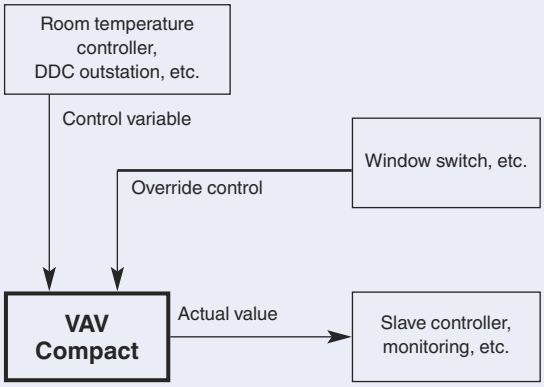
The controller can communicate on a MP bus (local network). Up to eight VAV Compact controllers can be addressed on one MP bus and can be integrated into following systems:

- LonWorks-systems using the Belimo interface UK24LON
- DDC outstation with integrated MP bus protocol

VAV Compact

1 VAV Compact
2 Gear release button
3 Tube connection for transducer
4 Connection for adjustment tool
5 Shaft clamp
6 Rotation angle limiter
7 Indicator lights
8 Connecting cable

VAV control



Technical data			
Supply voltage	24 V AC ± 20 %, 50/60 Hz, 24 V DC	Override control	Terminal 6, input resistance >300 kΩ Terminal 7, contact current >1 mA
Power rating	max. 3,5 VA (for AC voltage) max. 2 W (for DC voltage)	IEC protection class	III (Safe voltage)
Control signal	0 to 10 V DC, Ri >100 kΩ	Protection level	IP 54
Flow rate actual value signal	0 to 10 V DC linear, max. 0,5 mA	EMC	CE marking according to 89/336/EWG

3 Adjustment using the ZTH-VAV

Adjustment tool ZTH-VAV

Actual values can be read and parameters can be changed using the adjustment tool ZTH-VAV. The adjustment tool is connected directly to the VAV Compact or in the switch cabinet as shown in the wiring diagram.

Start-up window

```
LMV_D2_MP TR
```

Operation and changing of display

Use the arrow keys "↓" and "↑" to change the displays. The flow rates are displayed in l/s.

Attention: $\dot{V}_{Nom}$ must not be changed!

Setting of parameters

Select parameter using arrow keys. The actual value is shown. To calculate the values use formula shown on page 7.

Use "+" and "–" keys to set required value. Save value with "ok".

Example for $\dot{V}_{max}$:

```
Vmax          110l/s
Setpoint      300m3/h
```

Repeat procedure with $\dot{V}_{min}$.

Change of mode of operation

The mode (0 to 10 or 2 to 10 V) can only be changed, when the ZTH-VAV is in "Expert mode".

To enable the expert mode:

- Keep "ok" button pressed and connect the cable 7. The "Configuration menu" is shown.
- Use one of the arrow keys until "Expert mode" is shown.
- Set expert mode using "+" key to value 1 and save value with "ok".
- Use one of the arrow keys until "Leave expert mode" is shown.
- Confirm with "ok".

The expert mode remains enabled when the adjustment tool is disconnected, but can be disabled from the "Configuration menu".

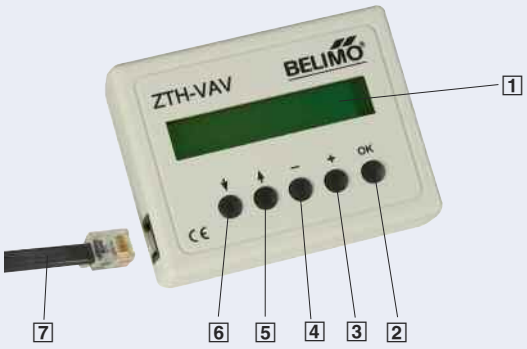
Example:

```
Mode          0.0-10.0V
-new              2-10V
```

Use "+" and "–" keys to set required value. Save value with "ok".

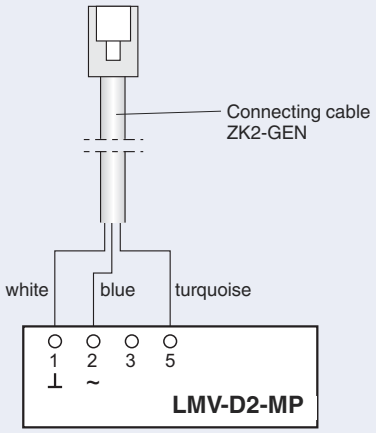
For further information about wiring and operation, see separate manual, No. M/ZTHVAV/EN/1

ZTH-VAV



1 Display
2 OK key
3 Plus key
4 Minus key
5 Arrow key "back"
6 Arrow key"forward"
7 Connecting cable with plug

Connection of ZTH-VAV to LMV-D2-MP



4 Functional description

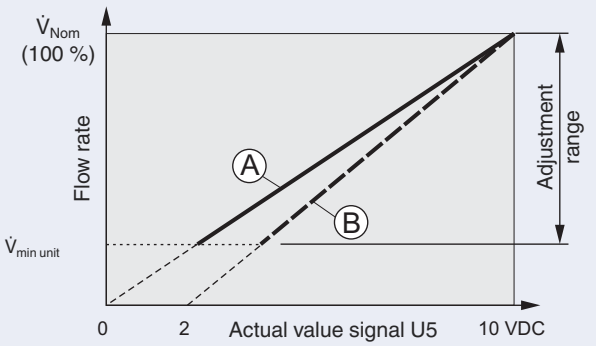
Functional description

The flow rate is measured using the dynamic differential pressure principle. The effective pressure Δp_w of the differential pressure sensor in the air terminal unit enables a partial volume flow passing through the transducer to be detected and measured. Two temperature-dependent resistors are used to measure this partial flow rate, which is, with temperature compensation, proportional to the total flow rate, this is then available, as a voltage signal. The linearisation of the flow rate signal is carried out in the controller.

The actual flow rate can be monitored as the voltage signal U5. The flow rate range is factory adjusted depending on the size of the unit so that 10 V DC corresponds to the unit nominal flow rate ($\dot{V}_{Nom}$).

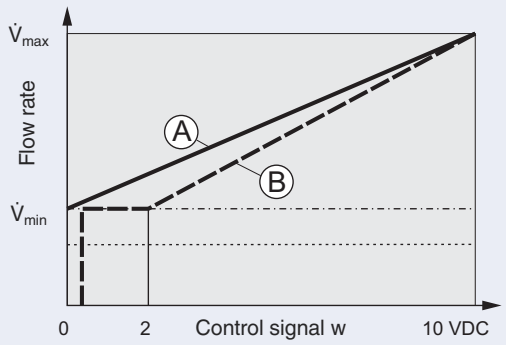
The required flow rate is set by the room temperature controller or by switch contacts. The controller determines the required flow rate in accordance with the characteristic shown and compares this with the actual value. The damper actuator is controlled based on the deviation. The factory set parameters $\dot{V}_{min}$ and $\dot{V}_{max}$ can be altered by the customer using an adjustment tool or a notebook with service tool.

Characteristic of actual value signal



Ⓐ 0 – 10 V DC	Ⓑ 2 – 10 V DC
$\dot{V}_{actual} = \dot{V}_{Nom} \frac{U5}{10}$	$\dot{V}_{actual} = \dot{V}_{Nom} \frac{U5-2}{8}$

Characteristics of the control signal



Ⓐ 0 – 10 V DC	Ⓑ 2 – 10 V DC
$\dot{V}_{Set} = \frac{w}{10} (\dot{V}_{max} - \dot{V}_{min}) + \dot{V}_{min}$	$\dot{V}_{Set} = \frac{w-2}{8} (\dot{V}_{max} - \dot{V}_{min}) + \dot{V}_{min}$

5 Flow rate control

Flow rate control

The flow rate controller operates independent of duct pressure, i.e. pressure fluctuations cause no changes to flow rate. To prevent the flow rate control becoming unstable, a band is provided within which the damper does not move. This dead band and the accuracy of the differential pressure sensor lead to a flow rate deviation $\Delta\dot{V}$ as shown in the figure opposite.

If the conditions given in the technical leaflet (e.g. minimum total pressure differential, upstream flow conditions) are not complied with, greater deviations must be expected.

$\dot{V}_{min}$-setting

The $\dot{V}_{min}$-value corresponds to the flow rate which is set with a 0 or 2 V DC control signal or $\dot{V}_{min}$-override control. $\dot{V}_{min}$ may be set between 0 and 100 % of $\dot{V}_{Nom}$. The percentage figures relate to $\dot{V}_{Nom}$.

At setpoint values lower than $\dot{V}_{min\ unit}$ the damper blade closes.

$\dot{V}_{max}$-setting

The $\dot{V}_{max}$-value corresponds to the flow rate which is set with a 10 V DC control signal or $\dot{V}_{max}$-override control. The setting range is from 30 to 100 %. The percentage figures relate to $\dot{V}_{Nom}$.

Flow rate adjustment on site

If site adjustments to the factory set flow rate values are required, $\dot{V}_{min}$ and/or $\dot{V}_{max}$ can be set to new values using formulae shown. Use adjustment tool ZTH-VAV or a notebook with service tool for resetting.

Tracking control

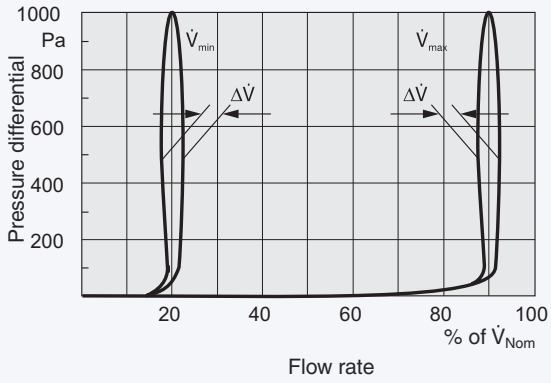
The VAV Compact only provides for ratio control, i.e. the supply (M) and extract (S) air must be in the same ratio under all operating conditions.

The flow rate ratio is set using the $\dot{V}_{max}$-parameter on the slave controller. The setting range is from 30 to 100 %.

Where the flow rates are the same and the units of equal size, the setting will be 100 %. If units are of different sizes then $V_{max\ S}$-setpoint value is calculated with the formula opposite. If $\dot{V}_{max\ S}$-setpoint value > 100 %, the master and slave functions must be reversed.

As a rule, the V_{min}-setpoint value on the slave is set to 0 %.

Pressure independent control characteristics



$$\dot{V}_{min}\text{-setpoint value} = \frac{\dot{V}_{min}}{\dot{V}_{Nom}} \times 100\ \%$$

$$\dot{V}\text{max-setpoint value} = \frac{\dot{V}_{max}}{\dot{V}_{Nom}} \times 100\ \%$$

$$\frac{\dot{V}_{max\ M}}{\dot{V}_{min\ M}} = \frac{\dot{V}_{max\ S}}{\dot{V}_{min\ S}}$$

$$\dot{V}_{max\ S}\text{-setpoint value} = \frac{\dot{V}_{max\ S}}{\dot{V}_{max\ M}} \times \frac{\dot{V}_{Nom\ M}}{\dot{V}_{Nom\ S}} \times 100\ \%$$

6 Functional indicators

Indicator lights and service buttons

The VAV Compact provides two indicator LED lights which also operate as push buttons.

Indicator light 1 on (green)

Indicator light 2 on (orange)

LED function table

Application	Function	Description / action	Lights pattern	
			Adaption ⊕	LED 1 Supply voltage
			Address ⊕	LED 2 Status
Operation	Status information	24 V AC-supply voltage ok, Controller ready to operate	LED 1	
			LED 2	
S1 service function	Synchronisation	Synchronisation triggered by: a) Adjustment tool b) Manual disengagement c) Power-ON behaviour	LED 1	Start … Sync time →
			LED 2	
S2 service function	Adaption	Adaption triggered by: a) Adjustment tool b) Button at controller	LED 1	Start … Adaption →
			LED 2	
V1 VAV service	VAV service active	a) "Adaption" and "Address" pressed simultaneously b) VAV service deactivated: – When 24 V AC disconnected – When the two buttons are pressed again – Automatically after 2 hours	LED 1	
			LED 2	↓
	Flow rate too low	Damper blade opens, because actual flow rate too low	LED 1	
			LED 2	
	Flow rate set	Set flow rate controlled	LED 1	
			LED 2	
	Flow rate too high	Damper blade closes, because actual flow rate too high	LED 1	
			LED 2	

7 Flow rate ranges

Flow rate ranges									
		in l/s				in m³/h			
		$\dot{V}_{min}$		$\dot{V}_{max}$		$\dot{V}_{min}$		$\dot{V}_{max}$	
		$\dot{V}_{min\ unit}$ [1]	up to	from	up to $\dot{V}_{Nom}$	$\dot{V}_{min\ unit}$ [1]	up to	from	up to $\dot{V}_{Nom}$
Nominal size		**TVZ · TVA · TVR · TVRK**							
100 [2]		10	95	30	95	36	342	108	342
125		15	150	45	150	54	540	162	540
160		25	250	75	250	90	900	270	900
200		40	405	120	405	144	1458	432	1458
250		60	615	185	615	216	2214	666	2214
315		105	1025	310	1025	378	3690	1116	3690
400		170	1680	505	1680	612	6048	1818	6048
B × H in mm		**TVJ · TVT**							
200		45	215	65	215	162	612	234	774
300		65	320	95	320	234	918	342	1152
400	**100**	85	425	130	425	306	1224	468	1530
500		105	535	160	535	378	1548	576	1926
600		130	650	95	650	468	1872	702	2340
200		85	415	125	415	306	1188	450	1494
300		125	620	185	620	450	1782	666	2232
400		165	825	250	825	594	2376	900	2970
500	**200**	205	1035	310	1035	738	2988	1116	3726
600		250	1250	375	1250	900	3600	1350	4500
700		290	1450	435	1450	1044	4176	1566	5220
800		330	1650	495	1650	1188	4752	1782	5940
300		185	920	275	920	666	2646	990	3312
400		245	1230	370	1230	882	3546	1332	4428
500		305	1535	460	1535	1098	4428	1656	5526
600	**300**	370	1850	555	1850	1332	5328	1998	6660
700		430	2150	645	2150	1548	6192	2322	7740
800		490	2450	735	2450	1764	7056	2646	8820
900		555	2770	830	2770	1998	7974	2988	9972
1000		620	3100	930	3100	2232	8928	3348	11160
400		325	1630	490	1630	1170	4698	1764	5868
500		410	2040	610	2040	1476	5868	2196	7344
600		490	2450	735	2450	1764	7056	2646	8820
700	**400**	570	2850	855	2850	2052	8208	3078	10260
800		650	3250	975	3250	2340	9360	3510	11700
900		735	3670	1100	3670	2646	10566	3960	13212
1000		820	4100	1230	4100	2952	11808	4428	14760
500		510	2540	760	2540	1836	7308	2736	9144
600		610	3050	915	3050	2196	8784	3294	10980
700	**500**	710	3550	1065	3550	2556	10224	3834	12780
800		810	4050	1215	4050	2916	11664	4374	14580
900		915	4570	1370	4570	3294	13158	4932	16452
1000		1020	5100	1530	5100	3672	14688	5508	18360
600		730	3650	1095	3650	2628	10512	3942	13140
700		850	4250	1275	4250	3060	12240	4590	15300
800	**600**	970	4850	1455	4850	3492	13968	5238	17460
900		1100	5500	1650	5500	3960	15840	5940	19800
1000		1220	6100	1830	6100	4392	17568	6588	21960
700		990	4950	1485	4950	3564	14256	5346	17820
800	**700**	1140	5700	1710	5700	4104	16416	6156	20520
900		1280	6400	1920	6400	4608	18432	6912	23040
1000		1420	7100	2130	7100	5112	20448	7668	25560
800		1300	6500	1950	6500	4680	18720	7020	23400
900	**800**	1460	7300	2190	7300	5256	21024	7884	26280
1000		1620	8100	2430	8100	5832	23328	8748	29160
900	**900**	1640	8200	2460	8200	5904	23616	8856	29520
1000		1820	9100	2730	9100	6552	26208	9828	32760
1000	**1000**	2020	10100	3030	10100	7272	29088	10908	36360

[1] $\dot{V}_{min}$ = 0 is also possible

[2] TVR only

8 Single duct units

Flow rate control tolerances[1]		
Flow rate in % of $\dot{V}_{Nom}$	$\Delta\dot{V}$ in ± %	
	TVZ, TVA, TVR, TVRK	TVJ, TVT
100	5	5
80	5	5
60	7	7
40	7	8
20	9	14
10	20	>14

[1] Percentages relative to $\dot{V}_{Act}$

Single duct units

Order code, order example

The available options are given in the current price list.

TVZ / 160 / 00 / BC0 / E2 - 150 – 400 l/s

TVR / 160 / 00 / BC0 / M2 - 50 – 240 l/s

TVA / 160 / 00 / BC0 / S2 - 50 – 240 l/s

Control mode	
E	Single
M	Master
S	Slave
F	Constant value

Voltage range	
0	0 to 10 V DC, standard range
2	2 to 10 V DC

Flow rate parameter	
Control mode	**Factory settings**
E2, E0 M2, M0	$\dot{V}_{min}$- and $\dot{V}_{max}$ factory set at required values
S2, S0	$\dot{V}_{min}$ at 0 % $\dot{V}_{max}$ factory set at flow rate ratio to the master controller
F2, F0	$\dot{V}_{min}$ factory set at required value $\dot{V}_{max}$ at 100 %

9 Dual duct units

TVM flow rate ranges				
Nominal size	l/s		m^3/h	
	$\dot{V}_{min\ unit}$	$\dot{V}_{Nom}$	$\dot{V}_{min\ unit}$	$\dot{V}_{Nom}$
125	45	150	162	540
160	75	250	270	900
200	120	405	432	1458
250	185	615	666	2214
315	310	1025	1116	3690
400	505	1680	1818	6048

Flow rate control tolerances[1]		
Flow rate in % of $\dot{V}_{Nom}$	$\Delta\dot{V}$ in ± %	
	TVM_{cold}	TVM_{total}
100	5	7
80	5	10
60	5	12
40	7	15
30	8	
20	9	
10	20	

[1] Percentages relative to $\dot{V}_{Act}$

Dual duct units

Order code, order example

The available options are given in the current price list.

TVM / 160 / 00 / BF0 / E2 - 150 - 400 l/s

Control mode	
E	Single
M	Master
F	Constant value

Voltage range	
0	0 to 10 V DC, standard range
2	2 to 10 V DC

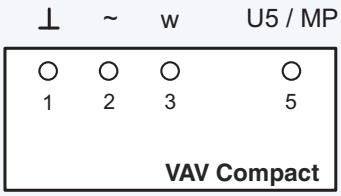
Flow rate parameter	
Control mode	**Factory settings**
E2, E0 M2, M0	$\dot{V}_{min}$ and $\dot{V}_{max}$ factory set at required values
F2, F0	$\dot{V}_{min}$ factory set at required value $\dot{V}_{max}$ at 100 %

10 Electrical wiring

Wiring

The 24 V supply voltage must be wired by the customer. Safety transformers must be used (EN 60742). If several flow rate controllers are connected to one 24 V network, it is important to ensure that a common neutral or ground wire is used and that this is not connected to any other wiring.

Terminal allocation



IMPORTANT

The examples illustrated show the most common arrangements for flow rate control. The generally accepted codes of practice must be observed in the overall control system design, selection of other control components and wire sizing.

Nomenclature

⊥	Ground
~	Supply voltage 24 V
w	Control signal input (0/2 to 10 V DC)
MP	MP bus
U5	Actual value signal output (0/2 to 10 V DC)

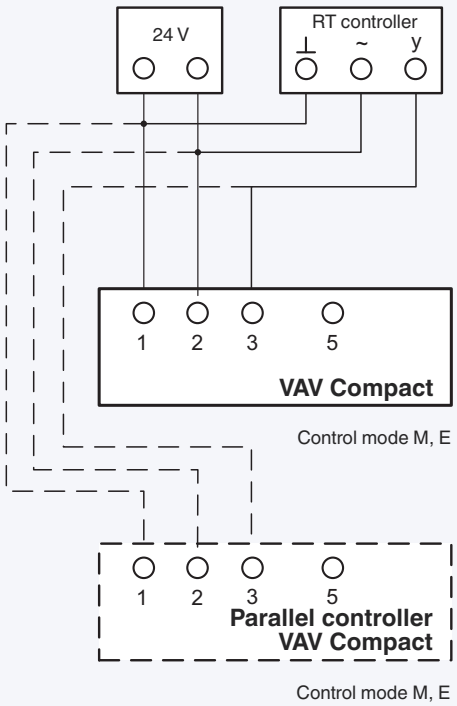
Room temperature control

A dedicated room temperature controller or a DDC outstation with 0/2 to 10 V DC output is connected with at least two wires (terminals 1 and 3) as shown opposite. If the controllers are on the same mains (24 V) make sure that terminal 1 of the VAV Compact is identical to the ground of the control signal.

Parallel control

Several flow rate controllers (supply or extract air) are run in parallel by one controller. If the air terminal units are of the same size and the $\dot{V}_{min}$- and $\dot{V}_{max}$-values are set the same, all units will control to the same flow rate. If there are different settings, then the controls will maintain a constant percentage between the flow rates.

Room temperature control and parallel control

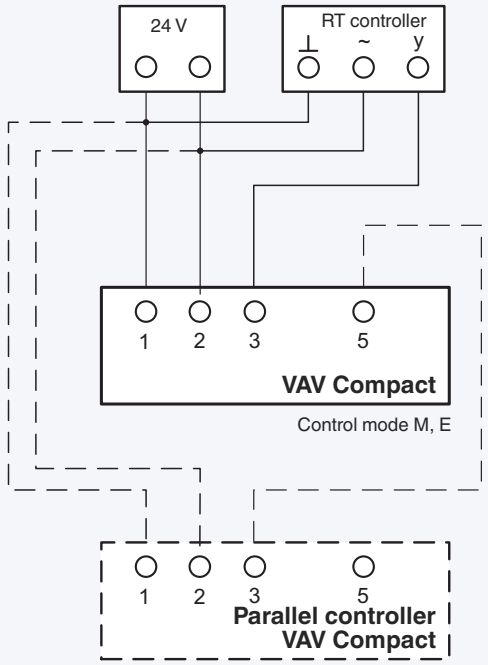


Supply - extract tracking control (Master/Slave)

If the units are controlled in parallel and if the pressure in one duct section is too low there may be an undesirable difference in flow rate between supply and extract air.

It is therefore more beneficial to use the actual value signal, usually that of the supply air, as the control signal for the slave flow rate (extract) controller.

Tracking control



Override controls

External switches (potential-free contacts) provided by the customer can override the variable flow rate control. These overrides can be applied separately for each controller or centrally as shown in the wiring diagram opposite.

Switch functions

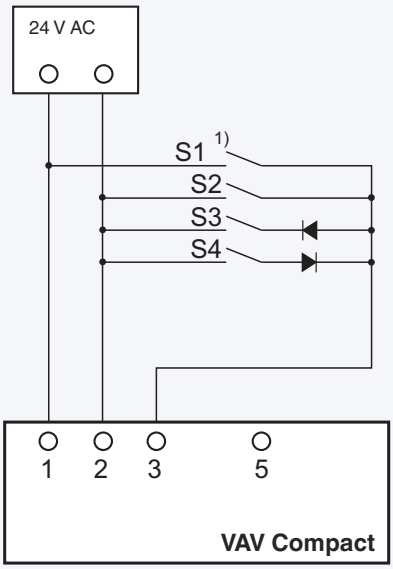
S1, S2, S3 and S4 open : $\dot{V}_{min}$
S1[1] closed : Damper blade Closed
S2 closed : $\dot{V}_{max}$
S3[2] closed : Damper blade Closed
S4 closed : Damper blade Open

[1] For 2 to 10 V DC
[2] For 0 to 10 V DC

IMPORTANT

When combining several override controls, the switches must be interlocked such that no short-circuit occur.

Override controls



Override control "Closed" for voltage range 2 to 10 V DC		
U3	**Flow rate**	**Control**
< 0.1 V DC	0	Damper blade closed, Inactive control
0.2 to 2 V DC	$\dot{V}_{min}$	Controlling $\dot{V}_{min}$
2 to 10 V DC	$\dot{V}_{min}$ – $\dot{V}_{max}$	Variable volume flow control

11 Dual duct terminal units type TVM

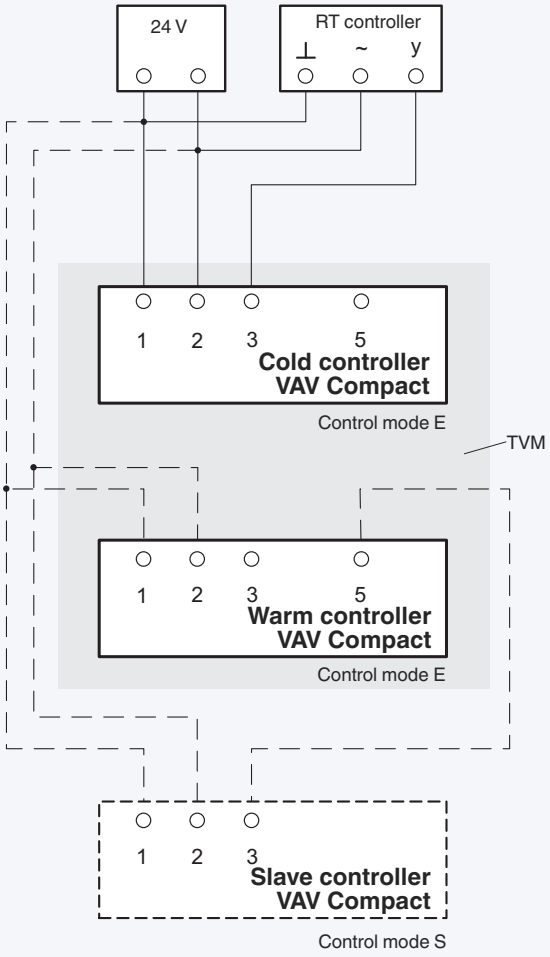
Flow rate control of TVM units

Two VAV Compacts are necessary in order to control a dual duct terminal unit type TVM.

The room temperature controller controls the cold duct flow rate controller. In most cases, the proportion of warm air is increased in the heating cycle from 0 to the required $\dot{V}_{min}$. The warm duct controller ($\dot{V}_{total}$ is measured) is therefore set as a constant flow rate controller and does not require a control signal.

If there is a tracking controller, e.g. for extract air, this controller operates as a slave controller with control mode S, and receives the actual value output signal of the warm flow rate controller as control signal.

Dual duct terminal units type TVM



12 Commissioning

Commissioning

With the indicator lights a functional test can easily be carried out. If the commissioning procedure is to include verification of the flow rate setpoint values $\dot{V}_{min}$ and $\dot{V}_{max}$, these must be set as described below. The actual value signal U5 is measured in each operating mode and the flow rate is then calculated.

In many cases, incorrect wiring can be the reason for malfunctions. To find faults:

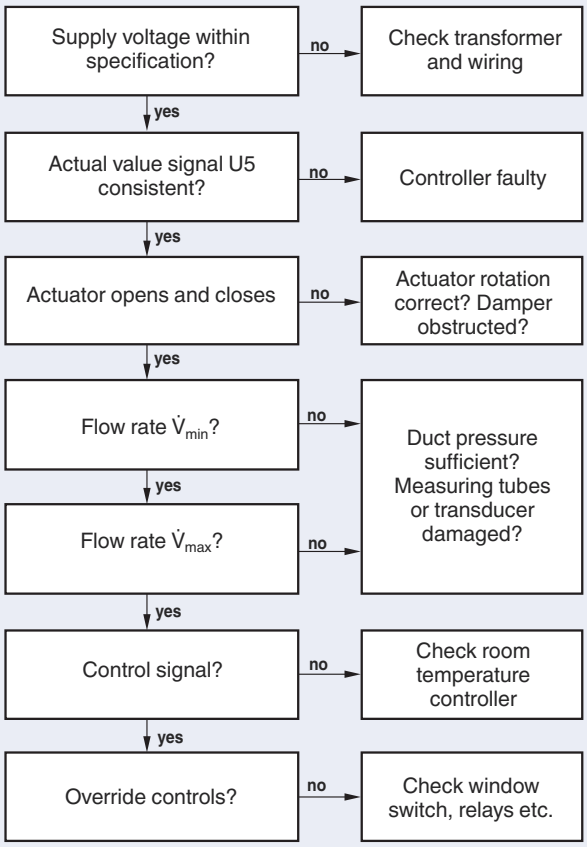
- Disconnect wiring from terminals 3 to 5
- Disengage actuator drive and open damper blade manually, the voltage U5 must increase
- Disconnect supply voltage for a short time to re-synchronise the actuator. (Otherwise the actuator remains at its current position.)
- Apply override control and test the required functions

The flow rate control is checked with a setpoint value to which the actual values must correspond after a short time. The setpoint is given by a voltage signal or using switches.

The functional check can be simplified using the adjustment tool ZTH-VAV, see page 4. The set flow rate values $\dot{V}_{min}$ and $\dot{V}_{max}$ can be read. Furthermore, the adjustment tool indicates whether the monitored value agrees with the set value.

Functional testing

Fault finding check



Replacement controller

When replacing faulty controllers, calibrated controllers set for the air terminal unit type and size must be used. Uncalibrated controllers can only be used as a temporary solution.

The following must be specified when ordering replacement controllers. This information can be found on the unit label and on the adjustment label of the unit.

- Terminal unit type and size, and in case of TVM units, warm or cold duct controller
- Operating mode
- $\dot{V}_{min}$ and $\dot{V}_{max}$
- Voltage range
- Delivery date of the faulty controller

Order example spare controller

Spare controller for
TVZ/125/00/BC0/E0 - 15 – 120 l/s (see label)

The TROX VAV Compact are equivalent to Belimo VAV-Compact as follows.

M466EN5	LMV-D2-MP
M466EP3	LMV-D2-MP-F
M466EE9	NMV-D2-MP