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## Product range overview

**VAV-Compact D3**

**Volumetric flow and section pressure control**

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<td>PC-Tool MFT-P</td>
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<td>CR24..</td>
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</tr>
<tr>
<td>Positioners</td>
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<td>CRP24..</td>
</tr>
</tbody>
</table>

* exclusively for VAV-Compact MP with integrated NFC interface (starting 2015).


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*2 / 48 S4-VAV-Compact D3 • en • v2.0 • 04.2015 • Subject to changes [www.belimo.eu](http://www.belimo.eu)*
VAV-Compact controller with integrated pressure sensor, VAV controller and damper actuator for pressure-independent VAV and CAV applications in the comfort zone

- Control:
  DC 0/2 ... 10V / MP-Bus
- Integration in bus systems
  – DDC controller with MP interface
  – LonWorks®/Modbus systems
  – Fan optimiser systems
- With additional switch-on option for sensors and switches
- Diagnostic socket for Service and PC-Tool
- NFC interface for Smartphone operation

### Brief description

#### Application
The digital VAV-Compact has PI control characteristics and is used for pressure-independent control of VAV units in the comfort zone.

#### Pressure measurement
The integrated maintenance-free Belimo D3 pressure valve sensor is also suitable for very small volumetric flows. It is for this reason that it enables versatile applications in the comfort zone, e.g. in residential construction, offices, hospitals, hotels, cruise ships, etc.

#### Actuator
Three versions available, depending on the size of the VAV unit: 5 / 10 / 20 Nm.
  – Rotary actuator, depending on the size
  – Linear actuator 150 N with 100, 200 or 300 mm linear movement

#### Control function
VAV-CAV or Open-Loop operation for integration in an external VAV control loop.

#### Feedback
Damper position for fan optimiser systems, current volumetric flow or pressure value.

#### VAV – variable volumetric flow
For variable volumetric flow applications with a modulating reference variable, e.g. room temperature controller, direct digital control or bus system, it enables demand-related, energy-saving ventilation of individual rooms or zones. The operating range \( V_{\text{min}} \ldots V_{\text{max}} \) can be connected via selectable mode.

The following are available: DC 2 ... 10V / 0 ... 10V / adjustable division / bus operation

#### CAV – constant volumetric flow
For constant volumetric flow applications, e.g. in step mode, controlled by means of a switch.

The following operating modes can be selected from: CLOSED / \( V_{\text{min}} \) / (\( V_{\text{mid}} \)) / \( V_{\text{max}} \) / OPEN

#### Bus function
Up to eight Belimo MP devices (VAV / damper actuator / valve actuator) can be connected together over the MP-Bus and integrated into the following systems:
  – LonWorks® applications with Belimo UK24LON interface
  – Konnex applications with Belimo UK24EIB interface
  – Modbus RTU applications with Belimo UK24MOD interface
  – BACnet applications with Belimo UK24BAC interface
  – DDC controller with integrated MP-Bus protocol
  – Fan optimiser applications with optimiser COU24-A-MP or DDC with Optimiser function
A sensor (0...10V or passive), e.g. a temperature sensor or a switch, can optionally be integrated into the higher-level direct digital control or bus system via the MP-Bus.

#### Operating and service devices
MP types: onboard NFC interface for Android Smartphone Assistant App.

#### Assembly and connection
The VAV-Compact device is connected using the prefabricated connecting cable.

#### Test function / test display
The VAV-Compact features two LEDs with a functional readiness display for commissioning and functional checking. Extended information with ZTH...

#### OEM factory settings
The VAV-Compact is mounted on the VAV unit by the unit manufacturer, who adjusts and tests it according to the application. The VAV-Compact is sold exclusively via the OEM channel for this reason.

### Type overview

<table>
<thead>
<tr>
<th>Type</th>
<th>Torque</th>
<th>Power consumption</th>
<th>Rating</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMV-D3-MP</td>
<td>5 Nm</td>
<td>2 W</td>
<td>3.5 VA (max. 8 A @ 5 ms)</td>
<td>Approx. 500 g</td>
</tr>
<tr>
<td>NMV-D3-MP</td>
<td>10 Nm</td>
<td>3 W</td>
<td>5 VA (max. 8 A @ 5 ms)</td>
<td>Approx. 700 g</td>
</tr>
<tr>
<td>SMV-D3-MP</td>
<td>20 Nm</td>
<td>3 W</td>
<td>5.5 VA (max. 8 A @ 5 ms)</td>
<td>Approx. 830 g</td>
</tr>
<tr>
<td>LHV-D3-MP</td>
<td>150 N</td>
<td>2.5 W</td>
<td>4.5 VA (max. 8 A @ 5 ms)</td>
<td>Approx. 550 g</td>
</tr>
</tbody>
</table>
Technical Data

Supply
Nominal voltage
AC 24V, 50/60 Hz
DC 24V
Operating range
AC 19.2 … 28.8 V
DC 21.6 … 28.8 V

Differential pressure sensor
Type, principle of operation
Belimo D3 sensor, dynamic response
Operating range
AC 0 … 600 Pa
DC ±3000 Pa
Installation position
Any, no reset necessary
Materials in contact with medium
Glass, epoxy resin, PA, TPE

Control function
– VAV-CAV
– Open-loop operation

Adjustment values
\( V_{nom} \)  
OEM-specific nominal volumetric flow setting, suitable for the VAV unit
\( \Delta p @ V_{nom} \)
38 ... 450 Pa
\( V_{max} \)
20 … 100% of \( V_{nom} \)
\( V_{min} \)
0 … 100% of \( V_{nom} \)
\( V_{mid} \)
50% of \( V_{min} \) to \( V_{max} \)

Classic control
VAV mode for reference value input \( Y \)  
( Connection 3)  
– DC 2 ... 10V / (4 ... 20 mA with 500 Ω resistance)
– DC 0 ... 10V / (0 ... 20 mA with 500 Ω resistance)
– Adjustable DC 0 ... 10V

Mode for actual value signal \( U_5 \)  
( Connection 5)  
– DC 2 ... 10V
– DC 0 ... 10V
– adjustable: volumetric flow, damper position or differential pressure

CAV operating modes (constant volumetric flow)
CLOSED / \( V_{min} \) / \( V_{mid} \) / \( V_{max} \) / OPEN * ( * only with AC 24V supply)

MP-Bus function
Address in bus operation
MP1 ... 8 (classic operation: PP)

LowWorks® / Konnex / Modbus RTU / BACnet
with BELIMO Interface UK24LON / UK24EIB / UK24MOD / UK24BAC
1 ... 8 BELIMO MP devices (VAV / damper actuator / valve)

DDC controller
DDC controllers/programmable controller with an integrated MP interface from various manufacturers

Fan optimiser (fan control)
with BELIMO Fan Optimiser COU24-A-MP

Sensor integration
Passive (Pt1000, Ni1000, etc.) and active sensors (0…10V), e.g. temperature, humidity
2-point signal (switching capacity 16 mA @ 24V), e.g. switches, occupancy switches

Operation and servicing
MP types: onboard NFC interface for Android Smartphone Assistant App, Pluggable / PC-Tool (V3.9 or higher) / service tool ZTH..

Communication
PP/MP-Bus, max. DC 15V, 1200 baud

Push-button
Adaption / addressing

LED display
– 24V supply
– Status / bus function

Actuator
Brushless, non-blocking actuator with power-save mode

Direction of rotation
left / right or ↑ / ↓

Adaptation
Capture of setting range and resolution to control range

Gear disengagement
Push-button self-resetting without functional impairment

Sound power level
max. 35 dB (A), SMV-D3-MP max. 45 dB (A)

Actuator - rotating
Angle of rotation
95°C, adjustable mechanical or electronic limiting
Position indication
Mechanical with pointer
Spindle holder
– Spindle clamp, spindle round 10 ... 20 mm / spindle square 8 ... 16 mm
– Form fit in various versions, e.g. 8 x 8 mm

Actuator – linear
Stroke
100, 200 or 300 mm, adjustable mechanical or electronic limiting
Connection
Cable, 4 x 0.75 mm²

Safety
Protection class
III Safety extra-low voltage
Degree of protection
IP54
EMC
CE according to 89/336/EEC

FCC: see US-relevant notes on page 47
VAV-Compact D3

Technical data (continued)

Safety
Mode of operation Type 1 (in acc. with EN 60730-1)
Rated impulse voltage 0.5 kV (in accordance with EN 60730-1)
Control pollution degree 2 (in accordance with EN 60730-1)
Ambient temperature 0 … +50°C
Non-operating temperature –20 … +80°C
Ambient humidity 5 … 95% r.h., non-condensing (in accordance with EN 60730-1)
Maintenance Maintenance-free

Connection

Connecting cable

The connection is made using the connecting cable mounted to the VAV-Compact device.

Note
– Supply via safety isolating transformer!
– Connections 1 and 2 (AC/DC 24V) and 5 (MP signal) must be routed to accessible terminals (room temperature controller, floor distributor, control cabinet, etc.) in order to enable access with the tool for diagnostic and service work.

VAV – Variable operation $V_{\text{min}}$–$V_{\text{max}}$

Wiring diagrams

Example 1:
VAV with analogue reference signal

Example 2:
VAV with shut-off (CLOSE), 2 … 10V mode

Example 3:
VAV with analogue reference signal
supply/exhaust air in parallel operation

Example 4:
VAV with analogue reference signal,
in Master/Slave operation
VAV-Compact D3

Technical data sheet

CAV – Step mode CLOSED / $V_{\text{min}}$ / $V_{\text{mid}}$ / $V_{\text{max}}$ / OPEN

### CAV control

**Note**

- Standard 0.5 V shut-off not use at:
  - Mode 2 ... 10 V and MP bus operation
  - Mode 2 ... 10 V and CAV control

**Wiring diagrams**

**Note**

The contacts are mutually interlocking!

**CAV function: Standard**

<table>
<thead>
<tr>
<th>Mode setting</th>
<th>$0 \ldots 10 \text{ V}$</th>
<th>$0 \ldots 10 \text{ V}$</th>
<th>$0 \ldots 10 \text{ V}$</th>
<th>$0 \ldots 10 \text{ V}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal</td>
<td>$2 \ldots 10 \text{ V}$</td>
<td>$2 \ldots 10 \text{ V}$</td>
<td>$2 \ldots 10 \text{ V}$</td>
<td>$2 \ldots 10 \text{ V}$</td>
</tr>
</tbody>
</table>

**Function**

- $V_{\text{min}}$ / $V_{\text{max}}$
- $V_{\text{mid}}$
- $V_{\text{max}}$

**Damper**

- CLOSED
- OPEN

**CAV**

- CLOSED
- OPEN

**Legend**

- Contact closed, function active
- Contact closed, function active, only in 2 ... 10 V mode
- Contact open

* Not available with DC 24 V supply.

**Example:**

CAV application CLOSED – $V_{\text{min}}$ – $V_{\text{max}}$

(mode 2 ... 10 V)

**CAV function: Old Generation (NMV-D2M)**

<table>
<thead>
<tr>
<th>Mode setting</th>
<th>$0 \ldots 10 \text{ V}$</th>
<th>$0 \ldots 10 \text{ V}$</th>
<th>$0 \ldots 10 \text{ V}$</th>
<th>$0 \ldots 10 \text{ V}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal</td>
<td>$2 \ldots 10 \text{ V}$</td>
<td>$2 \ldots 10 \text{ V}$</td>
<td>$2 \ldots 10 \text{ V}$</td>
<td>$2 \ldots 10 \text{ V}$</td>
</tr>
</tbody>
</table>

**Function**

- $V_{\text{min}}$ / $V_{\text{max}}$
- $V_{\text{mid}}$
- $V_{\text{max}}$

**Damper**

- CLOSED
- OPEN

**CAV**

- CLOSED
- OPEN

**Legend**

- Contact closed, function active
- Contact closed, function active, only in 2 ... 10 V mode
- Contact open

* Not available with DC 24 V supply.

**Example:**

CAV application $V_{\text{min}}$ – $V_{\text{mid}}$ – $V_{\text{max}}$

(mode 0 ... 10 or 2 ... 10 V)

**Note**

In order to use the CAV step $V_{\text{mid}}$, the Old Generation (NMV-D2M) CAV function must be selected.

**Note**

Supply via safety isolating transformer!

Connections 1 and 2 (AC/DC 24V) and 5 (MP signal) must be routed to accessible terminals (room temperature controller, floor distributor, control cabinet, etc.) in order to enable access with the tools for diagnostic and service work.
MP-Bus operation – VAV / CAV operation

Connecting cable

The connection to the MP-Bus is made using the connecting cable mounted to the VAV-Compact device.

Note

– Supply via safety isolating transformer!
– Connections 1 and 2 (AC/DC 24V) and 5 (MP signal) must be routed to accessible terminals (room temperature controller, floor distributor, control cabinet, etc.) in order to enable access with the tools for diagnostic and service work.

Wiring diagrams

Control via MP-Bus

For detailed information, see section «MP-Bus integration»

Control via MP-Bus with integrated switch

For detailed information on sensor integration, see section «MP-Bus integration»

Note

– For further information about the connection, override controls, MP-Bus cables, etc., see section «MP-Bus integration»
– This is a connection description. Depending on the application, the terminal allocation may vary. The connection and commissioning must be carried out by trained personnel.

Dimensioning of supply and connecting cable

General

In addition to the actual wire sizing, attention must also be paid to the surrounding area and the cable routing. Signal cables must not be laid in the vicinity of load cables, objects liable to cause EMC interference etc. if possible. Paired or layer stranded cables improve immunity to interference.

24 V supply, dimensioning and cabling

The dimensioning and installation of the AC 24V supply, the fuse protection and the cables are dependent on the total operated load and local regulations. Account must be taken of the following performance data, including the starting currents of the actuators:
– Dimensioning values VAV-Compact controller, see Technical data
– Dimensioning values of further controlling elements etc. can be found in the current data sheets and product information
– Other devices which are intended to be connected to the same 24 V supply
– Reserve capacity for subsequent expansion, if planned.

MP-Bus integration – supply, dimensioning and cabling

See S4-VAV-Compact D3, MP-Bus integration, page 33 … 42

<table>
<thead>
<tr>
<th>No.</th>
<th>Designation</th>
<th>Wire colour</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>black</td>
<td>AC/DC 24V supply</td>
</tr>
<tr>
<td>2</td>
<td>+ ~</td>
<td>red</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>~ Y</td>
<td>white</td>
<td>Input for – Sensor interface – Override control</td>
</tr>
<tr>
<td>5</td>
<td>~ U</td>
<td>orange</td>
<td>MP-Bus connection</td>
</tr>
</tbody>
</table>

*) e.g. window contact

*) MP address: 1 … 8

PC-Tool

ZTH-GEN

[..MV-D3-MP]

~ T

+ _ U Y

AC 24 V T ~

2 3 15

MP

–     +  DC 24 V

PC-Tool

ZTH-GEN

[..MV-D3-MP]

~ T

+ _ U Y

AC 24 V T ~

2 3 15

MP

–     +  DC 24 V

*) e.g. window contact
Tool connection

Settings and diagnostics

Belimo VAV operating and service devices
Smartphone operation – Belimo Assistant App
  – ZTH-GEN (replace by ZTH EU)
  – Service tool ZTH EU
Belimo PC-Tool, with level converter
  – ZIP-USB-MP
  – ZTH EU (with integrated MP-USB converter)

Smartphone – Belimo Assistant App

NFC-capable devices
  – LMV-D3-MP, NMV-D3-MP, SMV-D3-MP and
  – LHV-D3-MP with printed NFC mark

Non-NFC-capable versions
  – All devices without NFC mark
  – LMV-D3-MF
  – ...-D3LON, ...-MOD and ...-KNX

On-board service connection

The service connection integrated in the VAV-Compact enables rapid connection of the operating devices ZTH.. and PC-Tool.

For the PC-Tool connection, the PC is connected per USB cable with the level converter ZTH EU or ZIP-USB-MP.

MP connection (5)

The VAV-Compacts can also communicate with the Service tools via the MP connection (connection wire 5). The connection be set up during operations on-site, i.e. in the connection socket, on the tool socket of the Belimo room temperature controller CR24 or at the tier or control cabinet terminals.
Compatibility

Current overview
An overview of the compatibility of the VAV-Compact controller with current and replaced products can be found under www.belimo.eu.

VAV-Compact – Customer versions
A VAV-Compact in a customer version is a device which has been specially produced for a VAV unit manufacturer (OEM). These versions are adapted specifically for the sensors, damper spindles and fastening systems of the OEM.

Designation: ..V-D3-MP  yyy

1 Product designation, 2 Customer designation

Retrofit – old Belimo or VAV controllers from third-party manufacturers
A special retrofit set is available for replacing old VAV controllers. Please contact your local Belimo representative!

Replacement devices
When replacement devices are ordered, they are parameterised at the OEM factory in accordance with the installed system. The VAV-Compact controller is sold exclusively via the OEM channel for this reason.

Tool versions
See www.belimo.eu

Safety notes

• The device is not allowed to be used outside the specified field of application, especially in aircraft or in any other airborne means of transport.

• It may only be installed by suitably trained personnel. Legal regulations and regulations issued by authorities must be observed during installation.

• The device may only be opened at the manufacturer’s site. It does not contain any parts that can be replaced or repaired by the user.

• The cable must not be removed from the device.

• When calculating the torque required, the specifications supplied by the damper manufacturers (cross-section, construction, place of installation), and the ventilation conditions must be observed.

• The device contains electrical and electronic components and is not allowed to be disposed of as household refuse. All locally valid regulations and requirements must be observed.
VAV-Compact D3
Technical data sheet

Dimensions [mm]

<table>
<thead>
<tr>
<th>Dimensional drawings LMV-D3-..</th>
<th>Dimensional drawings NMV-D3-..</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Dimensional drawings SMV-D3-..</th>
</tr>
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<tbody>
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</table>

<table>
<thead>
<tr>
<th>Dimensional drawings LHV-D3-..</th>
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</thead>
<tbody>
<tr>
<td></td>
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<table>
<thead>
<tr>
<th>Type</th>
<th>Max. stroke</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHV-D3-MP100</td>
<td>100</td>
<td>233.5</td>
<td>264.2</td>
</tr>
<tr>
<td>LHV-D3-MP200</td>
<td>200</td>
<td>333.5</td>
<td>364.2</td>
</tr>
<tr>
<td>LHV-D3-MP300</td>
<td>300</td>
<td>433.5</td>
<td>464.2</td>
</tr>
</tbody>
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<td>15</td>
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<td>25</td>
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</tbody>
</table>
VAV-Compact D3

Functions

Volumetric flow measurement / setting

Principle of operation VAV-Compact

Block diagram

The pressure value signal from the sensor is converted in the measuring component (sensor electronics) into a signal proportional to the volumetric flow. The reference signal \( w \) is conditioned as a setpoint signal according to the operating volumetric flow setting \( V_{\text{min}}/V_{\text{max}} \).

The current system deviation acts as the control signal for the integrated actuator. The current volumetric flow is made available as an actual value signal for indicating and controlling slave VAV controllers.

In combination with a precise differential pressure sensor, the specially designed running time logic of the VAV-Compact guarantees high control quality for the VAV unit in which it is installed.

You can choose between control with a classic control signal or via the MP-Bus, depending on the application.

Volumetric flow measurement

The principle of the volumetric flow measurement is a pick-up device which is usually installed in the air duct in the form of a measuring diaphragm, a venturi nozzle or a measuring nozzle. Several measuring procedures have established themselves on the market for the recording of the volumetric flow.

Reliable and accurate differential pressure measurement – the key to exact volumetric flow control

The differential pressure measurement used by Belimo permits a reliable, averaging measurement, even with unfavourable inflow conditions.

Each of the sensors used for recording the differential pressure has its own dynamic behaviour. The influence of this measuring element in the volumetric flow calculation is designated the device constant \( c \).

The sensor element is comprised of a centrally located heating element with two temperature sensors aligned in the direction of the flow. A temperature 'dome' forms above the heating element which is deformed by the air flow in the direction of the flow. The resulting temperature difference between the two temperature sensors is a measure of the existing differential pressure on the sensor.

Features of the Belimo differential pressure sensor D3:

- Precise, proven heat transport measuring principle
- Minimal flow rate through the sensor, therefore insensitive to contamination
- Null measurement required neither at the time of commissioning nor during operation
- Suitable for every installation position
- Maintenance-free and with long-term stability for versatile applications
- Parallel measurements are possible thanks to the very low air flow rate
- Display of the current differential pressure of –600 … 600 Pa
- The direction of flow is detected

Legend:

\( V \) = Volumetric flow

\( c \) = Geometry-related constant of the baffle device

\( \Delta p \) = Differential pressure

\( \rho \) = Medium density

\[ \dot{V} = c \cdot \sqrt{\Delta p / \rho} \]
Volumetric flow measurement / setting (continued)

Nominal volumetric flow $\dot{V}_{\text{nom}}$

Energy and acoustic considerations mean that the specific volumetric flow for each duct diameter is not allowed to exceed a defined value. The binding nominal volumetric flows are fixed by the unit manufacturer, who is also responsible for the functionality of the VAV units. The nominal volumetric flow setting entails adapting the VAV-Compact to the installed VAV unit. The size, the nominal volumetric flow and the operating parameters are taken into account and set. $\dot{V}_{\text{nom}}$ corresponds to the maximum volumetric flow of the VAV unit at which the pressure drop and noise are still within the permissible operating conditions. The active calibration method used by Belimo, i.e. calibration with a reference volumetric flow, compensates any deviations due to mechanical tolerances in the manufacturing process. Since these values and the operating data of each VAV unit are unique, this process is carried out by the manufacturer when the unit is assembled in the factory.

No subsequent settings are necessary on the system – helping to significantly reduce installation and commissioning time and costs.

Operating volumetric flow setting $\dot{V}_{\text{min}} / \dot{V}_{\text{mid}} / \dot{V}_{\text{max}}$

The linear characteristic curve of the air volume controller enables the operating volumetric flows on the system side to be set easily. This setting is usually carried out either by the unit manufacturer or when the system is commissioned. $\dot{V}_{\text{max}}$ acts as the upper limit value as a function of the nominal volumetric flow. $\dot{V}_{\text{min}}$ can be set as a percentage of the required $\dot{V}_{\text{nom}}$.

For constant air volume (CAV), an intermediate position $\dot{V}_{\text{mid}}$ at 50% between $\dot{V}_{\text{min}}$ and $\dot{V}_{\text{max}}$ is available as needed.  

<table>
<thead>
<tr>
<th>Function</th>
<th>Volumetric flow</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\dot{V}_{\text{nom}}$</td>
<td>Nominal</td>
<td>OEM-specific value, depending on the VAV unit type and the application</td>
</tr>
<tr>
<td>$\dot{V}_{\text{max}}$</td>
<td>Maximum</td>
<td>20 … 100% of $\dot{V}_{\text{nom}}$</td>
</tr>
<tr>
<td>$\dot{V}_{\text{min}}$</td>
<td>Minimum</td>
<td>0 … 100% of $\dot{V}_{\text{nom}}$ (OEM-specific)</td>
</tr>
<tr>
<td>$\dot{V}_{\text{mid}}$</td>
<td>Intermediate position</td>
<td>between $\dot{V}<em>{\text{min}}$ and $\dot{V}</em>{\text{max}}$</td>
</tr>
</tbody>
</table>

* The minimum volumetric flow setting $\dot{V}_{\text{min}}$ varies according to the type of VAV unit.

1) Requires CAV setting: NMV-D2M-compatible, see page 6. Not available with DC 24 V supply.
VAV-Compact D3 Functions

Reference signal Y

**Behaviour in the lower control range**
The following descriptions explain the behaviour of the VAV-Compact D3 in the lower control range. The different behaviours arise on the one hand from the setting of the reference signal (0 ... 10V / 2 ... 10V) and on the other hand from the set value for $V_{\text{min}}$.

**Reference signal 0 ... 10V and $V_{\text{min}} > 0\%$**
As soon as the reference signal $[w]$ which is connected to terminal 3 [Y] of the controller falls below 0.5V, the volumetric flow unit adjusts to $V_{\text{min}}$ or to the lowest adjustable differential pressure.

**Note**
- Standard 0.5 V shut-off - not use at:
  - Mode 2 ... 10 V and MP bus operation
  - Mode 2 ... 10 V and CAV control

**Reference signal 2 ... 10V (or adjustable) and $V_{\text{min}} > 0\%$**
As soon as the reference signal $[w]$ which is connected to terminal 3 [Y] of the controller falls below 2.0V, the volumetric flow unit adjusts to $V_{\text{min}}$ or to the lowest adjustable differential pressure. The shut-off level (damper CLOSED) is fixed at 0.1V, but can if necessary be set with the PC-Tool to 0.5 V.

**Reference signal 0 ... 10V and $V_{\text{min}} = 0\%$**
The damper will close as soon as the reference signal $[w]$ which is connected to terminal 3 [Y] of the controller falls below 0.45V. The controller will return to control mode when the signal rises again above 0.55V.

**Reference signal 2 ... 10V and $V_{\text{min}} = 0\%$**
The damper will close as soon as the reference signal $[w]$ which is connected to terminal 3 [Y] of the controller falls below 2.36V. The controller will return to control mode when the signal rises again above 2.44V.
Three measured variables
The VAV-Compact provides three measured values to choose from as actual value signal:
• Volumetric flow as 0 … 100% \( \dot{V}_{\text{nom}} \) (default setting)
• Damper position as 0 … 100% of the available angle of rotation
• \( \Delta p \) actual value from 0 … 100% of \( \Delta p @ \dot{V}_{\text{nom}} \)
The setting can be switched with PC-Tool (Version V3.6 or higher).

Actual value signal \( U_5 \) – volumetric flow
The volumetric flow actual value signal \( U_5 \) indicates the current volumetric flow measured through the pick-up device of the VAV unit. This value corresponds to 0 … 100% of the set nominal volumetric flow. \( V_{\text{nom}} \) is set in the factory by the unit manufacturer and indicated on the VAV unit nameplate.

Application:
• Reference signal for the slave unit in master / slave applications
• Volumetric flow indication, e.g. on BMS, totalising function

Actual value signal \( U_5 \) – damper position
The damper position actual value signal indicates the current damper position.

Application:
• Indication, e.g. display on BMS
• Evaluation of the damper position for analogue-controlled fan optimisation
Actual value signal $U_5$ – differential pressure

The differential pressure actual value signal $U_5$ indicates the current differential pressure measured with the differential pressure sensor of the VAV unit.

This value corresponds to 0 ... 100% of the set $\Delta p @ V_{nom}$. This value is set in the factory by the unit manufacturer.

The actual value signal $U_5$ – differential pressure:

- Corresponds to 0 ... 100% $\Delta p @ V_{nom}$
- Indicates the currently existing differential pressure
- Has a shape that can be influenced by the mode and/or variable settings
- Must not be interconnected with the $U_5$ signals of other VAV-Compact controllers in conventional operation

Application:
- Pressure monitoring in Open Loop operation, e.g. filter monitoring
- Display, e.g. Display on BMS

Actual value signal $U_5$ – setting

- Influence of the mode setting on the actual value signal $U_5$
  The actual value signal $U_5$ is influenced by the set operating range. If the mode is set to 0 ... 10 V, the display range of the $U_5$ signal is 0 ... 10 V while if the mode is 2 ... 10 V, the display range is 2 ... 10 V.

- Adjustable actual value signal $U_5$
  The $U_5$ signal can be adapted with the PC-Tool $U_5$ feedback function for special applications; adjustable operating range:
  - Starting point DC 0.0 ... 8 V
  - End point DC 2.0 ... 10 V
CAV / VAV and open loop control functions

The VAV-Compact can be operated with either of two control functions:
- CAV / VAV operation (default setting)
- Open loop operation

The setting can be switched with PC-Tool (Version V3.6 or higher).

CAV / VAV operation

This control function corresponds to the conventional CAV / VAV function.
- CAV (constant air volume) control in step mode CLOSED / \( \dot{V}_{\text{min}} / \dot{V}_{\text{mid}} / \dot{V}_{\text{max}} / \text{OPEN} \).

For step control acting on input terminal 3, see page 6.

Application

Step-controlled CAV application, e.g.:
- Occupancy switch \( \dot{V}_{\text{min}} / \dot{V}_{\text{max}} \) or
- Meeting room with veto push-button for flushing mode \( \dot{V}_{\text{min}} / \dot{V}_{\text{max}} \)

The VAV-Compact adjusts the volumetric flow to the fixed selected value in constant air volume applications. One or more operating modes can be specified as required.

The following operating modes are available:

CLOSED / \( \dot{V}_{\text{min}} / \dot{V}_{\text{mid}} \) / \( \dot{V}_{\text{max}} / \text{OPEN} \)

- Shut-off operation – damper CLOSED:
  The damper is moved into the CLOSED position (0%).
- \( \dot{V}_{\text{max}} / \dot{V}_{\text{mid}} / \dot{V}_{\text{min}} \) operating modes:
  The VAV-Compact adjusts the volumetric flow to the fixed selected value.
- Flushing operation – damper OPEN:
  The damper can be opened (100%) for maximum ventilation, in which case air volume control is deactivated.

\(^1\) Requires CAV setting: NMV-D2M compatible, see page 6.

Not available with DC 24V supply.
**Functions**

**Control functions (continued)**

<table>
<thead>
<tr>
<th>Reference signal Y</th>
<th>Volumetric flow</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>(&lt; 0.1 \text{ V} ) (*\ (0.5 \text{ V}))</td>
<td>(0)</td>
<td>Damper CLOSED, VAV controller inactive</td>
</tr>
<tr>
<td>(0.2 \ldots 2 \text{ V} ) ((0.6 \ldots 2 \text{ V}))</td>
<td>(V_{\text{min}})</td>
<td>Operating level (V_{\text{max}}) active</td>
</tr>
<tr>
<td>(2 \ldots 10 \text{ V} )</td>
<td>(V_{\text{min}} \ldots V_{\text{max}})</td>
<td>Modulating operation (V_{\text{min}} \ldots V_{\text{max}})</td>
</tr>
</tbody>
</table>

\*Please note: The controller / DDC must be capable of pulling the reference signal to \(0 \text{ V}\).
Open-loop operation
This control function deactivates the integrated CAV / VAV control function. The VAV-Compact works as a modulating actuator with an integrated volumetric flow sensor.

- Typical application: Pressure-independent control of CAV / VAV units in the comfort zone, with utilisation of an external volumetric flow controller.
- Actuator, control via $Y$:
  - The actuator is controlled by means of an analogue control signal, e.g. 0 … 10 V, and moves to the defined position.
  - Running time: The running time in open loop mode is fixed at 150 s.
- Volumetric flow, measurement via $U_5$
  - Actual value signal: selectable signal (0 … 10 V or 2 … 10 V) corresponding to 0 … 100% $V_{nom}$. The $V_{nom}$ setting is made by the manufacturer of the VAV unit.

Open loop in MP-Bus mode
The open loop function was developed for analogue control. Open loop operation is available in principle, even in MP-Bus mode, although the transfer time of the data is still subject to the cycle time of the MP-Bus. Implementation of a VAV control loop through the MP-Bus, based on the open loop function, is for this reason not permitted.

### Application
New or retrofit solutions in connection with VAV controllers without actuator and sensor unit from various third-party manufacturers, e.g.:
- Siemens RXC ...
- TAC Xenta ...
- Differential pressure measurement via $U_5$
  - Actual value signal: selectable signal (0 … 10 V or 2 … 10 V) corresponding to 0 … 100% $\Delta p$ @ $V_{nom}$. The $\Delta p$ @ $V_{nom}$ setting is made by the manufacturer of the VAV unit.
**Master / slave connection**

In a master / slave connection, any changes in the air system of the master (supply pressure too low, e.g. due to a pressure control fault) are detected and reported to the slave. This guarantees an equal percentage ratio of supply air to exhaust air.

When are master / slave connections used?

- In systems with air volume controllers in the supply and exhaust air that are required to work sequentially
- When an equal percentage ratio of supply air to exhaust air is specified.

**Operating volumetric flow settings**

The $V_{\text{max}}$ and $V_{\text{min}}$ values used for the required volumetric flow are set on the master and transferred to the slave by means of a reference signal.

**CAV application**

In constant air volume applications, operating mode control (CLOSED / $V_{\text{min}}$ etc.) is only set on the master controller.

**Slave setting if the room pressure ratio is balanced**

The $V_{\text{min}}$ setting on the slave is always 0%. If the room pressure ratio is 1:1 and all controllers are the same size, the slave controller is set to $V_{\text{max}} = 100\% / V_{\text{min}} = 0\%$.

**Slave setting if the room pressure ratio is unbalanced**

The $V_{\text{min}}$ setting on the slave is always 0%.

**Setting with % scale on the ZTH-GEN service-tool**

The ratio of slave volume to master volume is set as follows with the $V_{\text{max}}$ value on the slave controller:

\[
V_{\text{max}} \% = \frac{V_{\text{max}} \cdot V_{\text{nom}} M}{V_{\text{max}} M \cdot V_{\text{nom}} S} \cdot 100
\]

\[
V_{\text{max}} M = \text{Nominal volume of the master unit in m}^3/\text{h}
\]

\[
V_{\text{max}} S = \text{Maximum volume of the slave unit in m}^3/\text{h}
\]

\[
V_{\text{nom}} M = \text{Nominal volume of the master unit in m}^3/\text{h}
\]

\[
V_{\text{nom}} S = \text{Nominal volume of the slave unit in m}^3/\text{h}
\]

**Setting with PC-Tool / ZTH-GEN**

These two setting tools can be used to enter the volumetric flow ratio directly in m$^3$/h, l/s or cfm, i.e. there is no need to calculate the setting ratio.

**Example**

**Required:** Positive pressure in the room with 20% excess air

- Supply air unit: $V_{\text{nom}} = 1600$ m$^3$/h / $V_{\text{max}} = 1500$ m$^3$/h
- Exhaust air unit: $V_{\text{nom}} = 2400$ m$^3$/h / $V_{\text{max}} = 1200$ m$^3$/h

**Find:** $V_{\text{max}}$ setting of the slave controller

\[
53\% = \frac{1200 \cdot 1600}{1500 \cdot 2400} \cdot 100
\]
Functions

Parallel connection

**Room pressure ratio**

In a parallel connection, the two VAV units are operated independently of one another with a common reference signal. The operating volumetric flows of the supply and exhaust air units must be set according to the required room pressure ratio.

The supply and exhaust air controllers work independently of one another, i.e. if a fault occurs in the supply or exhaust air system, the room pressure ratio is impaired for technical reasons. In the worst case, the unit tolerances may be accumulated. This circumstance must be taken into account by the project planning engineer.

**When are parallel connections used?**

- If air volume controllers operate with parallel supply and exhaust air (controlled by a common reference variable)
- If the supply and exhaust air devices have different sizes and different minimum and maximum volumetric flow settings
- If constant differential control is active between the supply and exhaust air
- In systems with several supply and exhaust air devices
- In circulating air systems for airtight rooms.

**Operating volumetric flow settings**

The $V_{\text{max}}$ and $V_{\text{min}}$ values used for the required volumetric flow must be set on each VAV controller.

**CAV application**

In constant air volume applications, operating mode control (CLOSED / Vmin etc.) is set on both controllers.

**Setting if the room pressure ratio is balanced**

Owing to the proportional assignment of the reference signal to the value ranges for $V_{\text{max}}$ and $V_{\text{min}}$, it is possible to operate VAV units with different nominal widths and differentiated ranges parallel to one another.

**Setting if the room pressure ratio is unbalanced**

The operating volumetric flows of the supply and exhaust air units must be set according to the difference:

- Positive pressure ratio in the room: Supply air volume > exhaust air volume
- Negative pressure ratio in the room: Exhaust air volume > supply air volume
Functions

Tool connection (1)
Enables the direct connection of a Belimo operating device, e.g.: PC-Tool, ZTH-GEN service tool for adjusting or checking the VAV-Compact. This connection is also available with an active MP integration.

Gear disengagement (2)
At the time of commissioning, the damper blade can be adjusted by hand with the aid of the push-button (2) on the VAV-Compact. Manual overrides are possible at any time – even under voltage – without limiting the functioning of the device. In order to avoid deviations in control mode, a synchronisation is carried out after each manual override – with visual display (4, Status LED).

Power and operating display (3)
The status of the 24V voltage supply and the operational readiness of the VAV-Compact is displayed by the green LED (Power).

Synchronisation (2) – with visual display (4)
In order to prevent permanent deviations caused by an actuation of the gear disengagement (2), a synchronisation of the position calculation is carried out. This ensures a correct position modulation of the damper blade. The progress of the function can be seen on the Status LED (4). Deviations caused by a manual override are excluded as a result. This synchronisation acts at the same time as a simple functional check. The synchronisation behaviour can be adjusted in accordance with the utilisation.

Angle of rotation adaption (3) – with visual display (4)
This function detects the upper and lower spindle end stops and stores them in the VAV-Compact. The running time and the working range are adapted to the available angle of rotation. Detection of the mechanical end stops enables a gentle approach to the end position and protects the actuator and damper mechanisms. The progress of the function can be seen on the Status LED (4). The adaption behaviour can be adjusted in accordance with the utilisation.

Bus function – Addressing (4)
During the addressing, the VAV-Compact is assigned an MP-Bus address (MP1 … 8) and the device is switched in bus function. For the process, see the section: MP-Bus integration

Display of active MP-PP communication (4)
During the addressing, the VAV-Compact is assigned an MP-Bus address (MP1 … 8) and the device is switched in bus function.

NFC logo (5) and NFC antenna range (6)
Devices with NFC logo (5) have the antenna in the area marked (6)
# LED function table

<table>
<thead>
<tr>
<th>Application</th>
<th>Function</th>
<th>Description / action</th>
<th>LED pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1 operation</td>
<td>Status information</td>
<td>– 24V power supply OK&lt;br&gt;– VAV-Compact ready for operation</td>
<td>LED 1&lt;br&gt;LED 2</td>
</tr>
<tr>
<td>S1 service function</td>
<td>Synchronisation</td>
<td>Synchronisation started by:&lt;br&gt;a) Operating / service device&lt;br&gt;b) Manual disengagement on the VAV-Compact&lt;br&gt;c) Power On behaviour</td>
<td>LED 1&lt;br&gt;LED 2</td>
</tr>
<tr>
<td>S2 service function</td>
<td>Adaption</td>
<td>Adaption started by:&lt;br&gt;a) Operating / service device&lt;br&gt;b) Button on VAV-Compact</td>
<td>LED 1&lt;br&gt;LED 2</td>
</tr>
<tr>
<td>B1 bus control</td>
<td>Addressing via MP master: (acknowledgement on VAV-Compact)</td>
<td>a) Addressing triggered on the MP master&lt;br&gt;b) Press the address pushbutton&lt;br&gt;LED indicates active communication again as soon as the addressing function has finished</td>
<td>LED 1&lt;br&gt;LED 2</td>
</tr>
<tr>
<td>B2 bus control</td>
<td>Addressing via MP master (with serial number)</td>
<td>Addressing triggered on the MP master, LED indicates active communication again as soon as the addressing function has finished</td>
<td>LED 1&lt;br&gt;LED 2</td>
</tr>
<tr>
<td>B3 bus control</td>
<td>MP-PP communication</td>
<td>Indicates active communication with the MP master or an operating / service device</td>
<td>LED 1&lt;br&gt;LED 2</td>
</tr>
</tbody>
</table>

**Legend:**
- Green LED (power) lit
- Yellow LED (status) lit
- Yellow LED lit intermittently
## Functions

### Settings

<table>
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<tr>
<th>Function</th>
<th>Adjustment values, limits</th>
<th>Operating device</th>
<th>Remarks, notes</th>
</tr>
</thead>
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<td></td>
<td></td>
</tr>
<tr>
<td>$V_{\text{max}}$</td>
<td>$20 \ldots 100%$ of $V_{\text{nom}}$</td>
<td>r / w</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{min}}$</td>
<td>$0 \ldots 100%$ of $V_{\text{nom}}$</td>
<td>r / w</td>
<td></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td>$0 \ldots 10V / 2 \ldots 10V$</td>
<td>r / w</td>
<td></td>
</tr>
<tr>
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<td>–</td>
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<td></td>
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<td>w</td>
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<td></td>
<td>– Stop &amp; Go ratio too high</td>
<td>r / w</td>
<td>–</td>
</tr>
<tr>
<td><strong>Series number</strong></td>
<td>nmnn-nmnn-nmnn-nmnn</td>
<td>r</td>
<td>r</td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>Type designation</td>
<td>r</td>
<td>r</td>
</tr>
</tbody>
</table>

Note: Setting data can be saved and printed out with the PC-Tool (V3.9.2 or higher).
The VAV-Compact controller records the following operating data, which can be uploaded via the PC-Tool or, in the case of MP-Bus integrations, via the MP-Bus master:

**Operating time**
Operating hours during which the VAV-Compact was connected to the supply.

**Active time**
Operating hours during which the VAV-Compact was mechanically in movement and was connected to the supply.

**Stop & Go ratio**
Ratio of active time/operating time (calculation = active time [h] / operating time [h] x 100)

The VAV-Compact generates the error messages described below under corresponding operating conditions. The error messages are legible with the PC-Tool and are displayed in the bus master with MP-Bus integrations.

"Actuation path increased"
If, in the case of an angle of rotation that is limited, e.g. to 60°, a mechanical defect (angle of rotation limitation incorrectly set or loose) causes the setting range to be suddenly >60°. This is detected by the VAV-Compact and the aforesaid message is generated.

**Mechanical overload**
The actuator is stopped before the expected end position of 0% or 100%. Possible causes include incorrect adaption, mechanical obstacle or that the damper requires an excessively high torque (is damaged, ageing). If this message is present, then the ring running of the damper and the area should be checked. Afterwards, the actuator should be readapted and the message deleted.

"Stop & Go ratio too high"
If the Stop & Go ratio exceeds 20% – i.e. the actuator is too often in movement in terms of its operating time – then the message “Stop & Go ratio too high” will be generated. Possible cause: an unstable reference signal, e.g. caused by swings in the upstream room temperature cascade.
## Table of contents

### Single duct plant
- CAV room solution with motion detector 28
- VAV room solution with 0 … 10V control 29
- VAV room solution with room controller CR24 30

### Dual duct installations
- VAV two-duct solution with room controller CR24 31

Additional VAV applications, including material lists and specification texts, can be found in the Applications library CR24 at www.belimo.eu

Energy-optimised VAV/CAV system solutions for fan regulations in the room ventilation applications.
Function and product description plus typical applications can be found in the System Documentation Optimiser COU24-A-MP at www.belimo.eu
Conventional applications

Single-duct systems

 IRC-VAV  CAV room solution with motion detector

Volumetric flow

~

Room occupied

~

Room not occupied

AC 24 V

Functional diagram

Control solution for CAV single-room application

CAV single-duct system, occupancy-controlled

Stand-alone operation or integrated in a building automation system (I/O integration)

Functions

The CAV controller is controlled by means of the motion detector in two modes on the basis of room occupancy \( V_{\text{min}} \) … \( V_{\text{max}} \):

- Room unoccupied: constant air volume \( V_{\text{min}} \)
- Room occupied: constant air volume \( V_{\text{max}} \)

Motion detector

With switching output for low switching capacity (load 0.24 mA)

VAV-Compact control device

..MV-D3-MP

VAV-Compact control device for supply air, exhaust air or mixing units, comprising a sensor, VAV controller and actuator for pressure-independent air volume controls.

Notes

1) Master-Slave
2) parallel

Mode setting on the CAV controller: 0 … 10 V oder 2 … 10 V
Conventional applications

**Single-duct systems**

**IRC-VAV**

**VAV-Compact D3**

**Conventional applications**

**Wiring diagram**

**Brief description**

Control solution for VAV single-room application

- VAV single-duct system, room temperature-controlled
- Stand-alone operation or integrated in a building automation system (I/O integration)

**Functions**

- The 0 ... 10 V single-room or DDC controller controls the VAV controller with a variable air volume in the range from $V_{\text{min}}$ ... $V_{\text{max}}$, depending on the room cooling needs.

**Single-room or DDC controller**

- With 0 ... 10 V output signal (cooling sequence).
- Controller functions in accordance with the manufacturer’s specification.

**VAV-Compact control device**

- MV-D3-MP
  - VAV-Compact control device for supply air, exhaust air or mixing units, comprising a sensor, VAV controller and actuator for pressure-independent air volume controls.

**Notes**

- Connection and terminal designations in accordance with the controller manufacturer’s specification
- Mode setting on the VAV controller: 0 ... 10 V
**VAV-Compact D3**

**Conventional applications**

**Single-duct systems**

**VAV room solution with CR24 room controller**

**Wiring diagram**

**Input and output assignment**

<table>
<thead>
<tr>
<th>Functions</th>
<th>Description</th>
<th>Assignment</th>
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<tr>
<td>VAV</td>
<td>VAV system output (0) 2 ... 10 V</td>
<td>Output ao1</td>
</tr>
<tr>
<td>Optional functions</td>
<td>Description</td>
<td>Assignment</td>
</tr>
<tr>
<td>EHO</td>
<td>Energy hold off (window)</td>
<td>Input di1</td>
</tr>
<tr>
<td>Sensor</td>
<td>External temperature sensor NTC 5K</td>
<td>Input ai1</td>
</tr>
<tr>
<td>Shift</td>
<td>External shift 0 ... 10 V (Summer / Winter compensation)</td>
<td>Input ai2</td>
</tr>
</tbody>
</table>

**Note**

Terminal designations in accordance with the Belimo final controlling element.

**Configuration, settings**

<table>
<thead>
<tr>
<th>DIP switches</th>
<th>1</th>
<th>P-Band</th>
<th>normal</th>
<th>wide</th>
</tr>
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<tbody>
<tr>
<td>2</td>
<td>di2</td>
<td>Stand by</td>
<td>Change over</td>
<td></td>
</tr>
</tbody>
</table>

**Notes**

- Further VAV applications such as boost (fast heat up), night cool down (air heated with water or electrically), night cooling, combination available with chilled ceiling. See www.belimo.eu
- Mode setting for VAV controller for this application: 2 ... 10 V

**Brief description**

Control solution for VAV single-room application

VAV single-duct system, room temperature-controlled

Stand-alone operation or integrated in a building automation system (I/O integration)

The CR24-B1 single-room controller controls the connected VAV controllers with a variable air volume in the range from $V_{\text{min}}$ ... $V_{\text{max}}$, depending on the room cooling needs.

Other functions can be optionally connected (e.g. with a motion detector): energy hold off, standby, etc.

Room temperature controller

CR24-B1

(automatic) CR24-A1

Room temperature controller (15 ... 36°C) with an integrated or external temperature sensor

- Mode selection with a pushbutton and three LEDs: AUTO, ECO (reduced room temperature for standby or night operation) and MAX (flushing operation with 15’ timer)
- Room protection function (frost / excess temperature)
- Inputs for energy hold off, standby operation, external temperature sensor, summer / winter compensation
- VAV system output
- Self-resetting start-up and service function
- Tool connection for diagnostics, settings and trend recordings

**Wiring diagram**

**Input and output assignment**

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**Setpoint WH range:** 15 ... 36 °C

**Functional diagram**

**Brief description**

Note

For technical data and a detailed description of functions, see CR24 product information.

**Functions**

- Room temperature controller
  - CR24-B1
  - (automatic) CR24-A1

**Wiring diagram**

**Input and output assignment**

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**Note**

Terminal designations in accordance with the Belimo final controlling element.

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</table>

**Setpoint WH range:** 15 ... 36 °C
**Conventional applications**

**Dual-duct systems**

**IRC-VAV**

**Functional diagram**

**VAV dual-duct solution with CR24 room controller**

**VAV dual-duct system, room temperature-controlled**

**Brief description**

**Information**

For technical data and a detailed description of functions, see CR24 product information.

**Control solution for VAV single-room application**

VAV dual-duct system, room temperature-controlled

Stand-alone operation or integrated in a building automation system (I/O integration)

**Functions**

The two air volume controllers mix the hot and cold air supplied by the dual-duct air conditioning system to obtain the condition requested by the CR24-B1 room temperature controller.

The constant air volume (CAV) controller for the hot air adjusts to the set maximum volume for heating. The variable air volume (VAV) controller for the cold air adds the variable amount of cold air requested by the room temperature controller. If cooling needs exceed the hot air volume, the hot-air part is shut off and only cold air is supplied.

**Optional:** The cold-air part can be shut off by means of a switching contact at input d1.

**Room temperature controller**

CR24-B1 (automatic) CR24-A1

- Room temperature controller (15 ... 36°C) with an integrated or external temperature sensor
- Mode selection with a pushbutton and three LEDs: AUTO, ECO (reduced room temperature for standby or night operation) and MAX (flushing operation with 15' timer)
- Room protection function (frost / excess temperature)
- Inputs for cold air shut-off, external temperature sensor, summer / winter compensation
- VAV system output
- Self-resetting start-up and service function
- Tool connection for diagnostics, settings and trend recordings

**VAV-Compact control device**

..MV-D3-MP

VAV-Compact control device for supply air, exhaust air or mixing units, comprising a sensor, VAV controller and actuator for pressure-independent air volume controls.

**Wiring diagram**

**Input and output allocation**

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<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shut-off CA</td>
<td>Cold air shut-off</td>
<td>Input di1</td>
</tr>
<tr>
<td>Sensor</td>
<td>External temperature sensor NTC 5K</td>
<td>Input ai1</td>
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**Configuration, settings**

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</table>

**Setpoint WH range:** 15 ... 36 °C

**Notes**

- Terminal descriptions correspond to the Belimo actuator connection.
- Mode setting for VAV controller for this application: 2 ... 10 V
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</tbody>
</table>
MP-Bus Integration

General

Conventional or via MP-Bus

VAV-Compact controllers can be controlled either conventionally or via the MP-Bus. Integrations in LonWorks®, EIB/Konnex, Modbus RTU, BACnet MS/TP or DDC systems with an MP interface can thus be realised simply and inexpensively.

Principle of operation

MP address

The assignment of an MP address turns a standard VAV-Compact into a bus-capable system controller with considerable added value.

In bus mode, the VAV-Compact controller is supplied with a reference signal over the MP-Bus from the higher-level building automation system and adjusts to the specified volumetric flow. The VAV-Compact is switched to MP-Bus mode automatically as soon as it is assigned an MP address. One active or passive sensor or one switch can be connected to each VAV-Compact. This input value can be used in the higher-level system, e.g. for VAV control in room temperature or other applications.

MP-Bus

The VAV-Compact can be interconnected with up to eight Belimo MP devices (damper actuators, valve actuators, VAV-Compact controllers) thanks to the integrated communication principle over the Belimo MP-Bus. These slave devices are supplied by the higher-level bus master with a digital control signal over the MP-Bus and then opened to the position dictated by this signal.

Integration for LonWorks®

The LonMark® certified UK24LON gateway connects the Belimo MP-Bus with LonWorks®. Up to eight MP actuators can be connected on the MP-Bus side. The UK24LON allows the actuators to be digitally controlled via the MP-Bus and send back their current operating status. It converts the digital information from the controller and the feedback into standardised network variables (SNVTs). The functions of the field devices can thus be directly integrated into LonWorks®.

Damper actuator object #8110

The actuator object is used to map the functions of the MP actuators to the LonWorks® network. There are eight of these objects in the UK24LON, i.e. one per MP actuator.

Open loop sensor object #1

An optional sensor or switch can be connected to each MP actuator. The open loop sensor object transfers the linked sensor values to the LonWorks® network. VAV controllers are also available in a LonMark® certified LON version as an alternative to cost-effective integration via the UK24LON: LMV-D3LON / NMV-D3LON.

Controller object #8060

A temperature controller is integrated in each actuator. This makes it easy to implement individual room control solutions.

For more detailed information, see UK24LON Product Information.
**MP-Bus Integration**

**Integration for EIB/Konnex, Modbus RTU and BACnet MS/TP systems**

The respective Belimo Gateway allows up to eight MP actuators or VAV-Compact controllers to be digitally controlled via the MP-Bus and to report back their current operating status. The digital information from the controller and the feedback are translated in the Gateway into telegrams of the respective field bus system. The functions of the MP field devices can thus be directly integrated into these systems.

**Sensor connection**

An optional sensor or switch can be connected to each MP actuator. The analogue sensor values are digitised in this way and transferred to the higher-level system.

For more detailed information, see product information UK24EIB, UK24MOD und UK24BAC.

**Integration with DDC / PLC controllers**

DDC / PLC devices with an MP interface are available from several manufacturers. These control devices can thus communicate directly and digitally with the connected MP field devices.

**Sensor integration**

An optional sensor or switch can be connected to each MP actuator. The analogue sensor values are digitised in this way and supplied to the DDC / PLC system for its control functions.

**MP-Bus protocol**

DDC / PLC manufacturers who would like to implement the MP-Bus protocol in their controllers can be provided with the technical specifications on request.

For more information, please contact the DDC / PLC supplier or your Belimo representative.

**Integration with COU24-A-MP Fan Optimiser**

MP-Bus controlled variable and constant air volume systems for room ventilation applications with fans controlled by a frequency converter.

The system is operated by the Fan Optimiser with optimum damper positions based on the current demand signals. The objective is to keep the pressure loss through the VAV units as low as possible and thus permanently reduce operating costs by decreasing the fan output. The damper positions of each VAV-Compact controller are recorded, transferred via the MP-Bus to the Fan Optimiser and used there as a control variable for regulating the fan controlled by the frequency converter.

As a result of this technology – which is based on the Belimo MP-Bus – up to 50% energy savings can be achieved compared to conventional systems with fans controlled by air-duct pressure.

**System size:** Any
**Number of VAV / CAV units per Fan Optimiser:** 1 … 8

For more detailed information, see
- COU24-A-MP Fan Optimiser system description
- COU24-A-MP product information
Addressing

Each device in a bus system must be uniquely identifiable. Each MP slave must therefore be assigned an address.

Address range: MP1 … 8

The slaves can be addressed either directly on the MP master unit or by means of a Belimo operating device. They are addressed using the serial number (numerical / barcode) or with the address pushbutton on the MP device.

Procedure: Refer to the documentation for the MP master unit or the PC-Tool online help (<F1> function).

Connection, MP-Bus topology, power supply and wiring

MP-Bus connection

The MP-Bus connection is a network for 1 … 8 Belimo MP devices. Like the VAV-Compact, it consists of a 3-pole connection for MP-Bus communication and the AC or DC 24 V power supply.

Neither special cables nor terminating resistors are required for the wiring.

The cable lengths (see calculation overleaf) are limited by:
- The sum of the performance data of the connected MP devices,
- The type of supply (AC 24 V via the bus or DC 24 V)
- The cable cross-section.

MP-Bus topology

The cables of up to eight MP devices / VAV controllers can be laid in a freely definable bus topology. The following topologies are permitted: star-shaped, ring-shaped, tree-shaped or mixed forms.
Cable lengths

Limits
The cable lengths (see calculation below) are limited by:
• The sum of the performance data of the connected devices, e.g. LMV-D3-MP 4 VA / 2 W
• The type of supply (AC 24 V or DC 24 V)
• The cable cross-section.

MP-Bus cable length for AC 24V supply via the bus cable

Total power rating of VAV controllers [VA]

Cable length vs. power rating applies to AC supply (minimum transformer voltage AC 21.6 V)

Calculation of the maximum cable lengths (AC 24V)
The power ratings (VA) of the individual devices must first be added together. The corresponding cable lengths can then be read from the graph.

Example:
MP-Bus with 5 x LMV-D3-MP
Total power rating: 5 x 4 VA = 20 VA

Values read from the graph:
• Cable with wire Ø 0.75 mm² requires: Cable length 28 m
• Cable with wire Ø 1.0 mm² requires: Cable length 40 m
• Cable with wire Ø 1.5 mm² requires: Cable length 54 m
• Cable with wire Ø 2.5 mm² requires: Cable length 100 m
Signal cable lengths (continued)

MP-Bus Integration

MP-Bus cable length for DC 24V supply via the bus cable

Total dimensioning of VAV controllers [W]

Calculation of the maximum cable lengths

The power consumption [W] of the individual devices must first be added together. The corresponding cable lengths can then be read from the graph.

Example:

MP-Bus with 5 x LMV-D3-MP
Total power rating: 5 x 2 W = 10 W

Values read from the graph:
- Cable with wire Ø 0.75 mm² requires: Cable length 75 m
- Cable with wire Ø 1.0 mm² requires: Cable length 100 m
- Cable with wire Ø 1.5 mm² requires: Cable length 130 m
- Cable with wire Ø 2.5 mm² requires: Cable length 250 m

Bus cable length for local AC 24V supply

Maximum length of bus cable for local AC 24V supply

If the VAV controllers are supplied locally with AC 24V via a separate transformer, the cable lengths can be significantly increased. The cable lengths indicated in the table apply regardless of the performance data of the connected actuators.
Control / operating volumetric flow settings

Reference variable and actual volumetric flow in bus mode

In bus mode, the reference variable is specified to the VAV-Compact as a digital signal by the higher-level system via the MP-Bus. The actual volumetric flow signal and the current damper position are supplied to this system for display or control functions.

The 0 ... 100% setpoint selected via the MP-Bus is resolved by the $V_{\text{min}} / V_{\text{max}}$ setting of the VAV-Compact controller, i.e.:
- 0% setpoint corresponds to $V_{\text{min}}$ volume
- 100% setpoint corresponds to $V_{\text{max}}$ volume

Operating volumetric flow setting $V_{\text{min}} / V_{\text{max}}$

**Function** | **Volumetric flow** | **Range**
--- | --- | ---
$V_{\text{nom}}$ | Nominal | OEM-specific value, depending on the application and the VAV unit type
$V_{\text{max}}$ | Maximum | 20 … 100% of $V_{\text{nom}}$
$V_{\text{min}}$ | Minimum | 0 * ... 100% of $V_{\text{nom}}$

* The $V_{\text{max}}$ must be set to 0% for shut-off operation. For VAV operation, on the other hand, a minimum value higher than the minimum setting limit should be used. See page 14.

Open operating volumetric flow setting

The $V_{\text{min}} / V_{\text{max}}$ setting can be open if necessary, i.e. the two values can be set to 0 and 100%. In this case, the volumetric flow must be limited in the higher-level system. This operating setting allows the limitation of the volumetric flow to be adjusted without altering the parameters on the VAV controller.

Responsibility for the limiting function passes from the OEM to the system supplier or integrator.

**Master / slave and parallel control**

**Master / slave control**

The actual volumetric flow is read from the master VAV controller by the higher-level system and specified to the slave controller as a reference signal.

**Parallel control**

If the VAV units are operated in parallel, the setpoints for the supply and exhaust air VAV units are transferred in parallel to the two VAV controllers.

**Positive and negative room pressure**

If a system with positive or negative room pressure is planned, the room pressure ratio must be taken into account in the setpoint calculation.
**VAV-Compact D3**  
**MP-Bus Integration**

<table>
<thead>
<tr>
<th>Bus fail function</th>
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</thead>
</table>

**Response to bus failure**  
It is possible to specify the response to an MP-Bus failure, essential maintenance work, faults, etc. on each VAV-Compact controller. This setting can be displayed or changed in PC-Tool (Version V3.9 or higher).

The following functions are available:
- CLOSED
- $V_{\text{min}}$
- $V_{\text{max}}$
- OPEN
- Last value (default setting, last setpoint command received from the bus master)
MP-Bus Integration

Sensor integration

Mode of operation

An additional sensor or switch can be connected to the VAV-Compact in MP-Bus mode independently of the VAV control loop. The sensor signal is connected to the reference value input that is not used in MP-Bus mode (connection 3). The VAV-Compact then acts as an analogue / digital converter for transmitting the sensor signal to the higher-level system. This system must know the physical address (which sensor is connected to which MP device) and be capable of interpreting the corresponding sensor signal. If possible, the sensors should be connected using separate cables to prevent compensation currents. The sensor ground (GND) cable, as a minimum, should be laid separately from the power supply cable over as long a distance as possible.

MP-Bus cycle time

Typical value 2 … 8 s
Dependent on the number of connected MP devices and sensors. The cycle time must be taken into account in the application and / or implementation!

Switching contact connection

For external switching contacts with control functions in the higher-level system, e.g. window switch for energy hold-off when the window is open, light switch (auxiliary contact) for occupancy-controlled standby circuit.
The cycle time must be taken into account in the implementation!

Switching contact requirement

The switching contact must be able to accurately switch a current of 16 mA at 24V.

Reference signal Y setting if a switch is connected

The VAV-Compact must be set to 2 … 10 V mode to enable the states of a connected switch to be evaluated:
The setting can be changed with PC-Tool or a ZTH...

Passive sensor connection

Passive resistance sensors, e.g: Pt1000, Ni1000, NTC, for open and closed-loop control functions in the higher-level system, such as a temperature sensor for monitoring the minimum room temperature. The cycle time must be taken into account in the implementation!

Reference signal Y setting for passive sensor integration

No special settings are required.

Active sensor connection

Active 0…10 V sensors for open and closed-loop control functions in the higher-level system, such as a humidity or CO2 sensor. The cycle time must be taken into account in the implementation!

Reference signal Y setting for active sensor integration

No special settings are required.
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- Analysis of faulty behaviour .................. 44
- Error description, symptoms, causes and rectification 45
Analyzing faulty behaviour

Symptoms, causes and rectification

Various fault symptoms, their possible causes and recommended rectification steps are described below.
Based on past experience, the faulty behaviour is probably due to the settings or control mode rather than to the air volume controller itself. A structured approach is essential to identify the most efficient remedy regardless of the particular malfunction:

Step 1: Determine and make a note of the actual state

Actual state
- Volumetric flow too low
- Supply air unit (master) Damper (100%) → open
- Exhaust air unit (slave): Damper in control range

Note the state:
- Reference signal w (#3) 6.5 V
- Actual value U5 (#5): 3.5 V
- Damper position 100%

Step 2: Functional check

Compare Damper 100% and volumetric flow too low
↓
«Insufficient volumetric flow, damper open in end position»

Cause
Supply air fan output too low

Step 3: Compare the faulty behaviour with the described symptoms

Rectify
- Check the supply air fan
- Rectify the fault

Step 4: • Rectify the fault
• Check the functions
## Functional check

### VAV-Compact D3

#### Fault descriptions, symptoms, causes and rectification

### Insufficient volumetric flow, damper OPEN in end position

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Possible cause</th>
<th>Rectification steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set volume not reached although damper is 100% open (end stop)</td>
<td>Air hoses between pick-up device and pressure sensor have been interchanged or are not connected</td>
<td>Monitoring with ZTH-GEN Connect air hoses correctly. Observe + / –</td>
</tr>
<tr>
<td></td>
<td>Fan failure</td>
<td>Check the fan, including the control functions, and rectify the fault</td>
</tr>
<tr>
<td></td>
<td>Fire dampers tripped, i.e. closed</td>
<td>Check whether all fire and/or shut-off dampers between the fan and the VAV unit are open</td>
</tr>
<tr>
<td></td>
<td>Fan air output too low</td>
<td>Check whether all fire and/or shut-off dampers between the fan and the VAV unit are open</td>
</tr>
<tr>
<td></td>
<td>Some or all rooms are often set positively (manually) to maximum volumetric flow when the system is started up. Consequence: The fan is unable to produce the required air output (simultaneity factor)</td>
<td>Deactivate override control and/or reduce the reference signal</td>
</tr>
</tbody>
</table>

### Insufficient volumetric flow, master damper OPEN / slave damper CLOSED

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Possible cause</th>
<th>Rectification steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set volume not reached:</td>
<td>VAV units in master / slave connection:</td>
<td>Check the fan in the line of the master unit and rectify the fault</td>
</tr>
<tr>
<td>• Damper of master unit is open</td>
<td>• Master in air shortage situation (fan defective or OFF), i.e. damper is 100% open</td>
<td>Check whether all fire and/or shut-off dampers between the fan and the master unit are open</td>
</tr>
<tr>
<td>• Damper of slave unit is closed</td>
<td>• Slave does not receive reference signal from master because master does not measure actual volume → damper CLOSED</td>
<td></td>
</tr>
</tbody>
</table>

### Volumetric flow too high, damper CLOSED

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Possible cause</th>
<th>Rectification steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set volume not reached and damper closed although reference signal is present</td>
<td>see «Behaviour in the lower control range», page 14</td>
<td>Increase the $V_{\text{min}}$ parameter Adjust the reference signal or correct the VAV-Compact mode setting</td>
</tr>
<tr>
<td>Damper closes (0%) instead of opening to $V_{\text{min}}$ value</td>
<td>VAV-Compact set to 2 … 10 V mode but controlled with 0 … 10 V reference signal</td>
<td>Change the VAV-Compact mode setting to 0 … 10 V</td>
</tr>
</tbody>
</table>

### Volumetric flow too high, damper OPEN

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Possible cause</th>
<th>Rectification steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual volume too high, damper open at end stop</td>
<td>Pressure hose squeezed off (jammed)</td>
<td>Check the pressure hoses: Mark the ± connections Pull the pressure hoses off of the VAV-Compact Blow through the hose lines</td>
</tr>
<tr>
<td></td>
<td>Note: The differential pressure sensor of the VAV-Compact does not normally need to be cleaned</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check the parts and clean them if necessary: Mark the ± connections Pull the pressure hoses off of the VAV-Compact Clean and blow out the pick-up device Blow through the hose lines Blow out the pressure sensor on the VAV-Compact and connect the hand pump to the (minus) connection. Remove any visible dirt Mount the pressure hoses Carry out a functional check</td>
</tr>
</tbody>
</table>

### Volumetric flow too low, damper in control range

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Possible cause</th>
<th>Rectification steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required volumetric flow not reached</td>
<td>Reference signal (DDC, room controller) limited by software</td>
<td>Check the reference signal (DDC, room controller) and adjust the limitation</td>
</tr>
<tr>
<td></td>
<td>VAV-Compact set to 2 … 10 V mode but controlled with 0 … 10 V reference signal</td>
<td>Correct the VAV-Compact mode setting</td>
</tr>
</tbody>
</table>
## VAV-Compact D3

### Functional check

#### Fault descriptions, symptoms, causes and rectification (continued)

## Volumetric flow too high, damper in control range

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Possible cause</th>
<th>Rectification steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steady-state deviation of volumetric flow (too high) relative to reference signal</td>
<td>VAV-Compact set to 0 ... 10 V mode but controlled with 2 ... 10 V reference signal</td>
<td>Adjust the reference signal or correct the VAV-Compact mode setting</td>
</tr>
</tbody>
</table>

## Positive / negative room pressure, damper in control range

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Possible cause</th>
<th>Rectification steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undesirable positive or negative pressure in room</td>
<td>Clamp loose, turns without spindle driver</td>
<td>Check the clamp mounting</td>
</tr>
<tr>
<td></td>
<td>Room pressure ratio not set correctly</td>
<td>Check the operating volumetric flow setting</td>
</tr>
<tr>
<td></td>
<td>Master / slave application with limited operating volumetric flow setting on slave controller</td>
<td>Check the operating volumetric flow setting. If the room pressure is balanced, the slave setting should be as follows: ( V_{\min} 0% / V_{\max} 100% ) (for an identical nominal width and air volume)</td>
</tr>
<tr>
<td></td>
<td>Wiring incorrect, VAV units interchanged (master / slave or parallel connection)</td>
<td>Check the wiring and correct it if necessary</td>
</tr>
</tbody>
</table>

**Example:**

Supply air office a and exhaust air office b
Supply air office b and exhaust air office a

VAV units set to master / slave but controlled in parallel

### Air volume controller does not react to reference signal

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Possible cause</th>
<th>Rectification steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAV controller adjusts to fixed value and does not react to reference signal changes</td>
<td>0 / 2 ... 10 V reference signal has no reference, i.e. ground connection (GND) is missing</td>
<td>Measure the signal between VAV-Compact terminals 1 (GND) and 3 (0 / 2 ... 10 V) Check the wiring and correct it if necessary</td>
</tr>
<tr>
<td></td>
<td>Polarity of reference signal and ground (GND) reversed</td>
<td>Measure the signal between VAV-Compact terminals 1 (GND) and 3 (0 / 2 ... 10 V) Check the wiring and correct it if necessary</td>
</tr>
<tr>
<td></td>
<td>AC 24 V connection reversed. If several devices are connected to the same AC 24 V transformer, this connection must be in phase</td>
<td>Check the wiring and correct it if necessary</td>
</tr>
</tbody>
</table>

### Damper does not move

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Possible cause</th>
<th>Rectification steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damper does not move</td>
<td>Clamp loose, turns without spindle driver</td>
<td>Check the clamp mounting</td>
</tr>
</tbody>
</table>
FCC notes

This device complies with part 15 of the FCC:
Operation is subject to the following two conditions:
1. This device may not cause harmful interference, and
2. this device must accept any interference received, including interference that may cause undesired operation.

The following statement applies to the products covered in this manual, unless otherwise specified herein. The statement for other products will appear in the accompanying documentation.

NOTE:
This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.
If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
– Reorient or relocate the receiving antenna.
– Increase the separation between the equipment and receiver.
– Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
– Consult the dealer or an experienced radio / T.V. technician for help.
All-inclusive.

5-year guarantee
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