Desigo -

Energy efficient applications: 
AirOptiControl

Application data sheet
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Subject to technical change.
1 Brief overview: AirOptiControl

AirOptiControl is an application to optimize air volume flow reducing energy consumption by up to 50% and offering, in this manner, an outstanding starting point for the highest level of energy efficient operation of ventilation and air conditioning plants for up to 10 rooms. At the same time, comfort control ensures that limit values are maintained for temperature, humidity and air quality.

The innovative application is modular in design and includes a number of plant variants to control air handling units and optimize fans. Moreover, demand-control per plant-side design of the control apparatuses allows for variable air volume flow (VAV). Both individual rooms and zones can be controlled via VAV control. Control of base load heating is an integral component of the application.

2 Basics

The most important task of air handling plants – in addition to guaranteeing thermally comfortable interior room conditions – is to ensure good indoor air quality at a minimum level of energy consumption.

Demand-control has increasingly prevailed on the market to achieve this goal. In other words, an optimized operation of air handling units, using air quality sensors and special control strategies at all load states, above all at partial loads, is employed to achieve ventilation per the determined air renewal demand at a good level of indoor air quality. Two important elements of demand-controlled ventilation are consideration of thermal tolerance ranges and reducing air volume flow by shutting down the plant at times applying special control strategies. The benefits of demand-controlled ventilation are found in the reduction of operating costs while automatically ensuring Comfort under all operational conditions.

It differs from the following conventional control strategies:

- Constant room air volume flow
- Variable room air volume flow, minimum (outside) air volume flow fixed by nominal occupancy of the room; increases subject to the room temperature control circuit
- Variable room air volume flow, demand-controlled subject to presence detector and/or air quality and room temperature control circuit

AirOptiControl takes it one step further:

- Variable room air volume flow, demand-controlled subject to presence detector and/or air quality and room temperature control circuit, coordination of rooms with air handling
2.1 Constant air flow rate

The constant air flow rate is guaranteed with a single-stage fan, using a scheduler to switch on or off. The entire ventilation plant is typically switched on in the morning and then switched off at night. A ventilation plant with constant air flow rate generally serves just one room or zone.

![Figure 2-1](image)

2.2 Variable air flow rate (staged)

Variable air volume (VAV) is understood as a ventilation plant that serves multiple rooms (or zones). The air flow rate to and from the rooms is controlled subject to the room temperature control circuit. The air handling unit is controlled by stages dependent on the presence sensors.

![Figure 2-2](image)

2.3 Demand-controlled ventilation (modulating)

Demand-control ventilation is understood as a ventilation plant that serves multiple rooms (or zones). The air flow rate to and from the rooms is controlled subject to the room temperature and air quality control circuit. The air handling unit is modulated controlled to a constant pressure or in stages dependent on the presence sensors.

![Figure 2-3](image)
2.4 AirOptiControl

AirOptiControl takes it a step further with a new kind of control algorithm and improves the energy balance sheet in a sustainable manner while maintaining defined comfort conditions.

The air flow rate to and from the rooms is controlled subject to the room temperature and air quality control circuit.

Air handling units are modulated controlled based on room demand signals for operating mode, air volume flow, temperature and humidity.

The following figure displays the required air volume rate during occupancy. You can clearly see that the room or air handling plant is shut down when no demand is requested from the rooms during defined occupancy.

![Figure 2-4](image-url)
3 AirOptiControl

3.1 Overview

AirOptiControl minimizes the air volume flow required by the rooms to ventilation and air condition using the following coordination functions:

– Temperature coordination:
  Supply air temperature is controlled dependent on room temperature demand.

– Air quality coordination:
  The recirculating dampers are controlled dependent on room air quality demand and then supplies only air to the room if they where there is demand and optimizes the transportation energy required using the following coordination functions:
  – Volume flow coordination:
    Controls speed of supply and extract air fans dependent on room air volume flow demand.
  – Energy efficiency control:
    The VAV dampers and plant are shut down when there is no volume flow demand.

The listed functions are explained in greater detail in following Sections.

Figure 3-1: AirOptiControl controls a plant for ventilation and air conditioning of up to 10 room in an energy efficient manner while maintaining room user-specific comfort conditions.
3.2 The most important energy efficiency functions

3.2.1 Demand-dependent control of fans, volume flow coordination

Advantages:
- Reduces fan electricity use by up to 50 %
- Less noise
- Improved control response

"Volume flow coordination" refers to the control of supply air and extract air fan speed dependent on air volume flow demand in the individual rooms. The fan speed is controlled in the function of the VAV damper positions or air volume flow control deviation so that at least one VAV damper is open as wide as possible. This destroys less pressure via the VAV dampers and keeps transportation energy to a minimum for the air volume flow as demanded by the room.

Comparison to a conventional control:
The fan is controlled to a constant pre-pressure regardless of room demand to supply all rooms with sufficient air at the design conditions. Considerable pressure is destroyed via VAV dampers at partial loads.

AirOptiControl provides two control strategies for volume flow coordination. You can select between the control strategies depending on the installed facility for volume flow control:
- VVS damper position
- Control deviation to volume flow control (setpoint – actual value)

3.2.2 Energy efficiency control and energy efficiency optimization

Advantages:
- Reduce operating time
- Reduce volume flow
- Early shut down of plant without impacting Comfort band

Plants are switched on and off by demand under energy efficiency control. Energy efficiency optimization increases a plant's thermal output to optimize operating time and thus lower fan energy.

![Diagram of Ahu Air handling unit with EefOpti Energy efficiency optimization, On/Off, DSptTR Delta room temperature setpoint, EnMaxArn Enable maximum air renewal, EefCtl Energy efficiency control, On/Off]

Figure 3-2

<table>
<thead>
<tr>
<th>Ahu</th>
<th>EefOpti</th>
<th>EefCtl</th>
<th>DSpTR</th>
<th>EnMaxArn</th>
<th>On/Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air handling unit</td>
<td>Energy efficiency optimization</td>
<td>Energy efficiency control</td>
<td>Delta room temperature setpoint</td>
<td>Enable maximum air renewal</td>
<td>On/Off</td>
</tr>
</tbody>
</table>
**Energy efficiency control**

VAV dampers and air handling plant are switched on and off in an energy efficient manner dependent on
- Room temperature
- Room humidity
- and room air quality.

The VAV dampers in the room are closed when the room control variables temperature, air quality and optional humidity achieve the switch off setpoints within the applicable comfort setpoint range. The air handling unit is switched off if the VAV dampers are closed for all rooms.

The plant is switched on again as soon as a room control variable violates the corresponding comfort setpoint range.

Symbols for energy efficient control mode in Desigo Insight

**Energy efficiency optimization.**

**Caution:** The function is only available to plants with a room or zone.

Output from the air handling unit is optimized by influencing the room temperature setpoints and the outside air portion. There are three optimization types:
- maximum heating,
- maximum cooling,
- maximum air renewal.

While operating, the system attempts to achieve the comfort setpoint range more quickly and reduce fan runtime even more by using increased thermal output or increased outside air portion.

Symbols for energy efficient optimization mode in Desigo Insight:

- Maximum heating: Room temperature setpoint is increased
- Maximum cooling: Room temperature setpoint is reduced
- Maximum outside air portion: Outside air portion is increased

**3.2.3 Demand-controlled control of mixed air dampers, air quality coordination**

**Benefit:**
- Reduce volume flow

"Air quality coordination" refers to control of the outside air portion dependent on room air quality demand in the individual rooms. The mixed air dampers are controlled in the function of control deviation to room air quality so that the outside air portion is increased for air quality demand in the room. This keeps air volume flow demand to a minimum in the rooms.

Comparison to a conventional control:
The outside air portion is controlled to a set minimum value, regardless of room demand, corresponding to the number of people in the rooms per defined planned values.
3.2.4 Demand-dependent control of supply air temperature, temperature coordination

Benefit:
- Reduce volume flow

"Temperature coordination" refers to control of the supply air temperature dependent on room air quality demand in the individual rooms. The supply air temperature is controlled in the function of control deviation of room temperature so that the supply air temperature is increased or lowered for temperature demand in the room before the air volume flow must be increased in the room to maintain the temperature. This keeps air volume flow demand to a minimum in the rooms.

Comparison to conventional control:
The supply air temperature is controlled to a set adjustment or setpoint adjusted to outside air temperature regardless of room demand.

3.2.5 Radiator control and demand-dependent control of heating group

Advantages:
- Reduces heating energy outside occupancy
- Simultaneous cooling and heating not possible
- Meets EN 15232 in class A

Radiator control in the room is an integral part of the AirOptiControl application to integrate room temperature control and coordination with the heating group. At first glance, this seems trivial, but in practice, the radiators are often controlled autonomously to room demand without coordination with the heating group.

3.2.6 Additional functions

- Modular designed standard library applications including graphics and plant operation using Desigo Insight to operate ventilation and air conditioning plants
- Control of air handling unit for multiple plant variants
- Night cooling to reduce cooling energy
- Window contract to save energy by locking room comfort control when a window is open
- Presence detector for additional optimization
- Room temperature setpoint corrections for additional Comfort
- Trending each for air handling units and rooms
- Primary plants can be equipped for partial air conditioning or full air conditioning
- Heat demand message from radiator to heating group
- AirOptiControl is suited for operating together with Total Room Automation
4 Energy savings

Comprehensive trials on real plants under lab conditions and building simulations consistently indicate energy savings in the neighborhood of 50%. Data in the comparison below in Table 4-1 using a benchmark solution corresponding to building type for a Swiss educational facility.

Further, optimization of volume flow coordination was conducted as part of a comprehensive simulation study in cooperation with the Fraunhofer-Institut IIS/SCS in Nuremburg (Germany).

Building:
Typical educational facility in Switzerland with 10 rooms

Primary plant:
Heating: Natural gas boiler, centralized ventilation plant with heating coil
Cooling: Refrigeration machine, centralized ventilation plant with air coolers

Room:
Measurements: Temperature and air quality
Air system: Supply and extract air - VAV

<table>
<thead>
<tr>
<th>Benchmark (BM)</th>
<th>AirOptiControl functionality 1 (AOC 1)</th>
<th>AirOptiControl functionality 2 (AOC 2)</th>
<th>AirOptiControl functionality 3 (AOC 3)</th>
<th>AirOptiControl functionality 4 (AOC 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan control</td>
<td>Constant air pressure</td>
<td>Demand control</td>
<td>Demand control</td>
<td>Demand control</td>
</tr>
<tr>
<td>Energy efficiency control</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Mixing air damper control</td>
<td>Constant outside air flow</td>
<td>Constant outside air flow</td>
<td>Constant outside air flow</td>
<td>Demand control</td>
</tr>
<tr>
<td>Supply air temperature control</td>
<td>Shifted by outside temperature</td>
<td>Shifted by outside temperature</td>
<td>Shifted by outside temperature</td>
<td>Demand control</td>
</tr>
<tr>
<td>Night cooling</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Energy and cost saving compared to benchmark; Building type "Educational facility"

<table>
<thead>
<tr>
<th>Cost saving</th>
<th>0.6 EUR/m²/Year</th>
<th>1.9 EUR/m²/Year</th>
<th>3.1 EUR/m²/Year</th>
<th>3.1 EUR/m²/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy saving</td>
<td>4.5 kWh/m²/Year</td>
<td>20.1 kWh/m²/Year</td>
<td>36.4 kWh/m²/Year</td>
<td>38.1 kWh/m²/Year</td>
</tr>
<tr>
<td>Cost saving</td>
<td>10 %</td>
<td>31 %</td>
<td>51 %</td>
<td>52 %</td>
</tr>
<tr>
<td>Energy saving</td>
<td>6 %</td>
<td>26 %</td>
<td>48 %</td>
<td>50 %</td>
</tr>
</tbody>
</table>

Table 4-1: Compare functions as well as energy and cost savings from the AirOptiControl control strategy for partial and complete systems against the benchmark control strategy.

Additional images are available in the appendix.
4.1.1 Maximum savings

The greatest savings are always available under "AirOptiControl functionality 4 (AOC 4)". The figure below illustrates the savings available to the different types of energy.

![Energy saving with AirOptiControl](image)

**Figure 4-1**

5 Advantages and customer benefits

5.1 Advantages

- "Energy Efficiency Control" with the potential to maximize energy savings from operating ventilation and air conditioning plants for up to 10 rooms
- Maximum reduction to air volume flow, adapted to actual demand
- Comfort control to maintain limits for temperature / humidity / air quality
- Strategy includes radiator control as base load heating or heating sequence
- Modular designed standard library applications including graphics for plant operation using Desigo Insight for simplified engineering and commissioning
- Information on savings based on a benchmark

5.2 Customer benefits

- Potential to cut operating costs in half thanks to significant and proven energy savings versus traditional applications
- Cuts amortization period thanks to significant energy savings versus traditional applications
- Suitable for existing plants, since optimization is achieved using purely control-technical measures without costly modifications to plant hardware
- Concrete means of sustainably reducing CO₂ thanks to massive energy savings
- The operating mode "Energy Efficiency Control" lowers maintenance costs since the plants can be shutdown during occupancy
- Reduced installation costs, thanks to the use of decentralized TX modules
– Time and costs savings during the engineering, commissioning and occupancy phases as well as lower service costs thanks to tested applications and detailed documentation
– Meets the highest energy class in EN15232 and increases the value of the plant as well as the potential resale value of the building

![BACS Energy Performance Classes – EN 15232](image)

Figure 4-2

6 Field of application

The exceptional energy savings using AirOptiControl yield the most at partial load operation. In other words, rooms with loads that vary strongly, for example
– large level of public traffic and changes in the number of people
– variable numbers of people and activities that change
– slight changes in the number of people with variable periods of machine use

The following list outlines applications where it makes sense to use AirOptiControl:
– Restaurants and cafeterias
– Lecture halls and schools
– Shopping malls and department stores
– Exhibition halls and gyms
– Lobbies, reception areas, banks, airport check in
– Convention halls
– Conference rooms, theaters and cinemas
– Larger offices and meeting rooms
– Manufacturing and assembly halls

The application can be used on both new and existing plants.
7 Amortization period

The following table provides examples of amortization periods for modernizations. The amortization period is calculated from annual energy savings and investment.

<table>
<thead>
<tr>
<th>Starting point</th>
<th>Modernization</th>
<th>Amortization period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing demand-controlled ventilation plant with 10 rooms (Temperature and air quality sensor) Automation station: - Visonik BPS128 with PTM modules</td>
<td>Modernization to Desigo PXC100 with TX I/O modules</td>
<td>&lt; 3 years</td>
</tr>
<tr>
<td>Existing VAV plant with 10 rooms (temperature sensor) Automation station: - Unigy PRU128 with PTM modules</td>
<td>Modernization to Desigo PXC100 with TX I/O modules and installation of IAQ sensor</td>
<td>&lt; 4 years</td>
</tr>
</tbody>
</table>

Both examples are based on the same plant type (primary plant and 10 rooms) in an office building with ca. 3,000 m² floor space and an existing partial ventilation plant implemented a few years prior using a Siemens automation station. The investment includes Desigo system hardware as well as standard services such as engineering and commissioning.

Conclusion:
Investment forecasts are interesting and may be worth the effort for plants serving large floor space.
AirOptiControl may also be worth it for smaller plants, if gains in health, comfort and the environment as well as increased value of the building come to the forefront of discussions.
8 Display

Prepared plant images for the air handling unit as well as room or zone are available in Desigo Insight.

Figure 8-1: Overview of operating elements for the air handling unit and centralized functions.

Key on number on the edge of the image:

1 - 4 "Operation": Setpoints are calculated using room demand signals
5 "Roomgroups": Setpoints and scheduler values apply simultaneously for multiple rooms

Figure 8-2: Overview of individual room operating graphics and details on energy efficiency operation.
9 System hardware

The AirOptiControl application is released for installation on the PXC-100/200 automation stations.
– for installation on the PXC-100/200 automation stations
or
– for distributed installation on PXC-100/200 automation stations and PXC3.. as part of TRA.

10 Field Devices

No special requires are placed on field devices with regard to measuring precision, quality, etc.
Siemens field devices should be used whenever possible.

11 Limits

The application is prepared for ventilation and air conditioning plants for up to 10 rooms.
AirOptiControl can be used as of Desigo V4.1.

Desigo V4.1/V5
The AirOptiControl application can be fully installed on a PXC-100/200.
The application is predefined to control ventilation and air conditioning plants featuring up to 10 rooms.

Desigo V5
The AirOptiControl application can be distributed to PXC-100/200 for primary plant control, and to PXC3.. (TRA) for room control.
12 Appendix
12.1 Benchmark
12.1.1 Display by energy cost savings [EUR/m²/year]

Figure 12-1

12.1.2 Display by energy savings [kWh/m²/year]

Figure 12-1
12.1.3 Display by cost savings [%]

Figure 12-3

12.1.4 Display by energy savings [%]

Figure 12-4
## 12.2 Plant components

The AirOptiControl application is modular in design with variants and options to adapt the application to the widest possible range of ventilation and air conditioning plants. It provides solid coverage of typical ranges on both the room as well as air handing unit side.

Support and unsupported components using AirOptiControl:

<table>
<thead>
<tr>
<th>Components</th>
<th>AirOptiControl</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air handling unit.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cooling</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Humidification</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Dehumidification</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Mixing with recirculated air</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Heat recovery</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Fan, single-speed,</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>two-speed, modulated</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Room</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VVS damper control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Position of damper position</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>- Setpoint / actual deviation</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Air volume</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air quality sensor</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Temperature sensor</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Humidity sensor</td>
<td>X</td>
<td>Place in extract air, jointly for all rooms</td>
</tr>
<tr>
<td>Presence detector</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Window contact</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Control radiator actuator</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Room manual switch</td>
<td>O</td>
<td>Not recommended for energy efficiency operation</td>
</tr>
<tr>
<td>(Auto, Off, On)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Setpoint temperature correction</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>Lighting control</td>
<td>N</td>
<td>Not recommended, must occur with specific devices</td>
</tr>
<tr>
<td>Solar protection control</td>
<td>N</td>
<td>Not recommended, must occur with specific devices</td>
</tr>
<tr>
<td>QAX room operator unit</td>
<td>N</td>
<td>Room operating units may be engineered at additional expense</td>
</tr>
<tr>
<td>More than 10 zones or rooms</td>
<td>N</td>
<td>More than 10 zones or rooms are possible with additional engineering and applying Desigo system limits</td>
</tr>
</tbody>
</table>

X  Supported  O  Option  N  Not supported
12.3 Installation topologies

Interesting topologies are possible using the Desigo island bus extension module to reduce overall installation costs (e.g. cabling). The following figures display three types of installation.

Centralized installation

Decentralized installation per room

Decentralized installation, grouping of rooms

Key

You can divide the topology by primary plant and rooms if two automation stations are required to implement the plant.

For Total Room Automation (TRA), distribution is between primary plant (PXC100/200) and rooms (PXC3..) TRA.
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