Basic principles and standards of building automation

In recent years, standards for building and room automation have been set by international committees to make the functionalities of building automation measurable and to be able to implement them efficiently. The energy efficiency of a building describes the relationship between the energy used and the resulting benefit. The latter must always be seen in relation to the function of a building and is an important factor in the evaluation of energy efficiency.

DIN EN 15232:
energy efficiency of buildings
European norm EN 15232 describes the effect of building automation and building management on energy efficiency and enables standardised representation for the first time. It includes a structured list of all building automation functions that can affect the energy efficiency of a building. It also offers systematic support for the definition of minimum requirements concerning building automation. The following can be stated as a basic principle: the higher the level of automation, the greater the energy savings.

Equivalent to highly energy-efficient BAC systems and TBM	A
Equivalent to more advanced BAC systems and some special TBM functions	B
Equivalent to standard BAC systems	C
Equivalent to BAC systems that are not energy-efficient. Buildings with such systems must be modernised. New buildings must not be constructed using systems such as these.	D

Building Automation and Control System (BAC), Technical Building Management (TBM)

We reserve the right to make technical changes.

Exemplary application of EN 15232

Automatic control and regulation of the heating system		**Definition of classes**							
		Residential building				Non-residential building			
		D	C	B	A	D	C	B	A
Control of transfer									
	The controller is installed at transfer level or room level; in the former case, one controller can regulate a number of different rooms.								
0	No automatic control	x				x			
1	Central automatic regulation	x	x			x			
2	Automatic individual room control using thermostatic valves or electronic control devices	x	x			x	x		
3	Individual room control with communication between control devices and BACs	x	x	x		x	x	x	
4	Integrated individual room control including needs-based regulation (occupancy, air quality, etc.)	x	x	x	x	x	x	x	x
Regulation of hot water temperature in distribution network (flow or return)									
	Comparable functions can be used to control networks for direct electrical heating.								
0	No automatic control	x				x			
1	Weather-based control	x	x			x	x		
2	Control of inside temperature	x	x	x	x	x	x	x	x
Control of circulation pumps									
	The controlled pumps can be installed in the network at different levels.								
0	No control	x				x			
1	On/off control	x	x			x			
2	Control of variable pump speed according to a constant Δp	x	x	x	x	x	x	x	x
3	Control of variable pump speed according to proportional Δp	x	x	x	x	x	x	x	x
Control of transfer and/or distribution during intermittent operation									
	One controller can regulate different rooms/zones with the same occupancy pattern.								
0	No automatic control	x				x			
1	Automatic control with fixed time program	x	x			x			
2	Automatic control with optimised on/off switching	x	x	x	x	x	x	x	x
Control of generators									
0	Constant temperature	x				x			
1	Variable temperature dependent on the outside temperature	x	x	x	x	x	x	x	x
2	Variable temperature dependent on the load	x	x	x	x	x	x	x	x
Operating sequence of different generators									
0	Priority setting based solely on the load	x	x			x	x		
1	Priority setting based on the load and on the generator performance	x	x	x		x	x	x	
2	Priority setting based on the level of generator usage (check other norms)	x	x	x	x	x	x	x	x

Source: DIN EN 15232

The table illustrates the relationship between building automation functions and energy efficiency classes for control of the heating system.

Application of EN 15232 gives rise to different energy efficiency factors for different building types, with regard to the use of thermal and electrical energy. In the evaluation of buildings, the energy efficiency class C is the reference class for the implementation of measures for energy optimisation.

The red field in the table on the right-hand side shows how the thermal energy consumption of a building with efficiency class A with a factor of 0.7 can be reduced by up to 30%.

Building Automation and Control (BAC) **Efficiency classes EN 15232**		**Efficiency factor for thermal energy**			**Efficiency factor for electrical energy**		
		Office	School	Hotel	Office	School	Hotel
A	Highly efficient Building Automation and Control System (BACS) and Technical Building Management (TBM)	0.70	0.80	0.68	0.87	0.86	0.90
B	Advanced BACS and TBM	0.80	0.88	0.85	0.93	0.93	0.95
C	Standard BACS	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
D	Non-efficient BACS	1.51	1.20	1.31	1.10	1.07	1.07

Source: DIN EN 15232, table 9, table 11

Use in room automation

VDI 3813 – room automation

VDI 3813 describes the integrated room automation with special consideration for interoperability of different building systems, based on usage requirements. To provide a uniform assessment basis for owners, planners and system integrators, clear terms and functions are defined in the norm.

The current difficulty is that in invitations to tender, room automation functions are dealt with separately from the building systems connected with technical development. In practice, this often means that existing potential for saving energy remains unused.

The VDI 3813 supplements the EN 15232 by providing a precise description of the room automation functions described there. It is important that EN 15232 and VDI 3813 are applied as early as the basic evaluation and pre-planning stage.

The table on the right-hand side shows the room automation functions of the VDI 3813, relating to the energy efficiency classes of EN 15232.

Application function	**BAC efficiency classes in accordance with DIN EN 15232**			
	D	C	B	A
Basic functions affecting energy efficiency				
Occupancy control			x	x
Time program			x	x
Illumination functions which influence energy efficiency				
Light switching		x		
Automatic lighting			x	x
Daylight switching			x	x
Constant light control			x	x
Solar shading functions which influence energy efficiency				
Automatic solar shading		x		
Louvre adjustment			x	x
Shading correction			x	x
Thermo-automatic control			x	x
Air conditioning functions				
Energy level selection			x	x
Energy level selection with start optimisation			x	x
Target value calculation			x	x
Function selection			x	x
Temperature control (heating/cooling)		x	x	x
Room/intake air temperature cascade control			x	x
Ventilator control			x	x
Sequence control			x	x
Setpoint control			x	x
Air quality control/regulation				x
Night cooling			x	x
Load optimisation			x	x

Source: VDI 3813 part 2

We reserve the right to make technical changes.

In room automation, sensors are implemented depending on their function and not on the individual building system. This saves on hardware and cabling costs as early as in the system installation phase. The reduction in cabling also has a positive spin-off effect on fire loads and building statics.

To achieve energy efficiency class A in accordance with EN 15232, Beckhoff offers a software library based on room automation guideline VDI 3813.

Comprehensive room automation exploits the interdependencies of facade control, illumination and climate control to create a pleasant room climate. At the same time, efficient room and zone control also affects the primary systems: the heating and cooling requirements and the air quantities are regulated according to need. When designing the heating, cooling, ventilation and air conditioning systems, the needs arising from the specific use of the building must be taken into account. A further benefit lies in the way in which a majority of the optimisation functions can be realised within the software on a single system during commissioning and ongoing operations. As a result, no reconstruction work impedes operation and the time required for software adjustment also remains within reasonable limits. In certain cases, many modifications can be made by accessing the system remotely, without the need for a service technician to attend in person.

The adjacent matrix shows the interplay of the individual building systems with regard to the sensors used. For energy efficient automation, all individual building systems must be controlled and managed from a single system.

Interaction of building systems	Sensor system					
	HVAC	Lighting	Solar shading	Security	Global	Monitoring
Light intensity	x	x	x			
Room temperature	x		x			x
Occupancy	x	x	x	x		x
Window contact	x		x	x	x	
Room operating device	x	x	x			
Weather (wind/rain)			x		x	
Outside temperature	x		x		x	
Solar radiation	x	x	x		x	

Offices according to energy efficiency class A

For a better illustration of what lies behind building automation functions and how energy can be saved, examples of building automation functions in an office with energy efficiency class A are described below.

Technical equipment of an office
Illumination consists of one lighting strip on the corridor side and one on the window side. The lights are held at a constant room brightness level via DALI (constant light control), depending on the amount of daylight. A room brightness sensor is mounted in the ceiling. An occupancy sensor is installed for needs-dependent management and control of the entire room.

The office is shaded by means of two electrically operated, externally mounted louvre blinds. Two buttons are installed for manual control of the blinds.

To heat the room, a radiator is present. The office is cooled via a cooling ceiling. An actuator is located on the radiator and on the cooling ceiling respectively. The room temperature is monitored and the desired room temperature is adjusted locally using EnOcean radio technology.

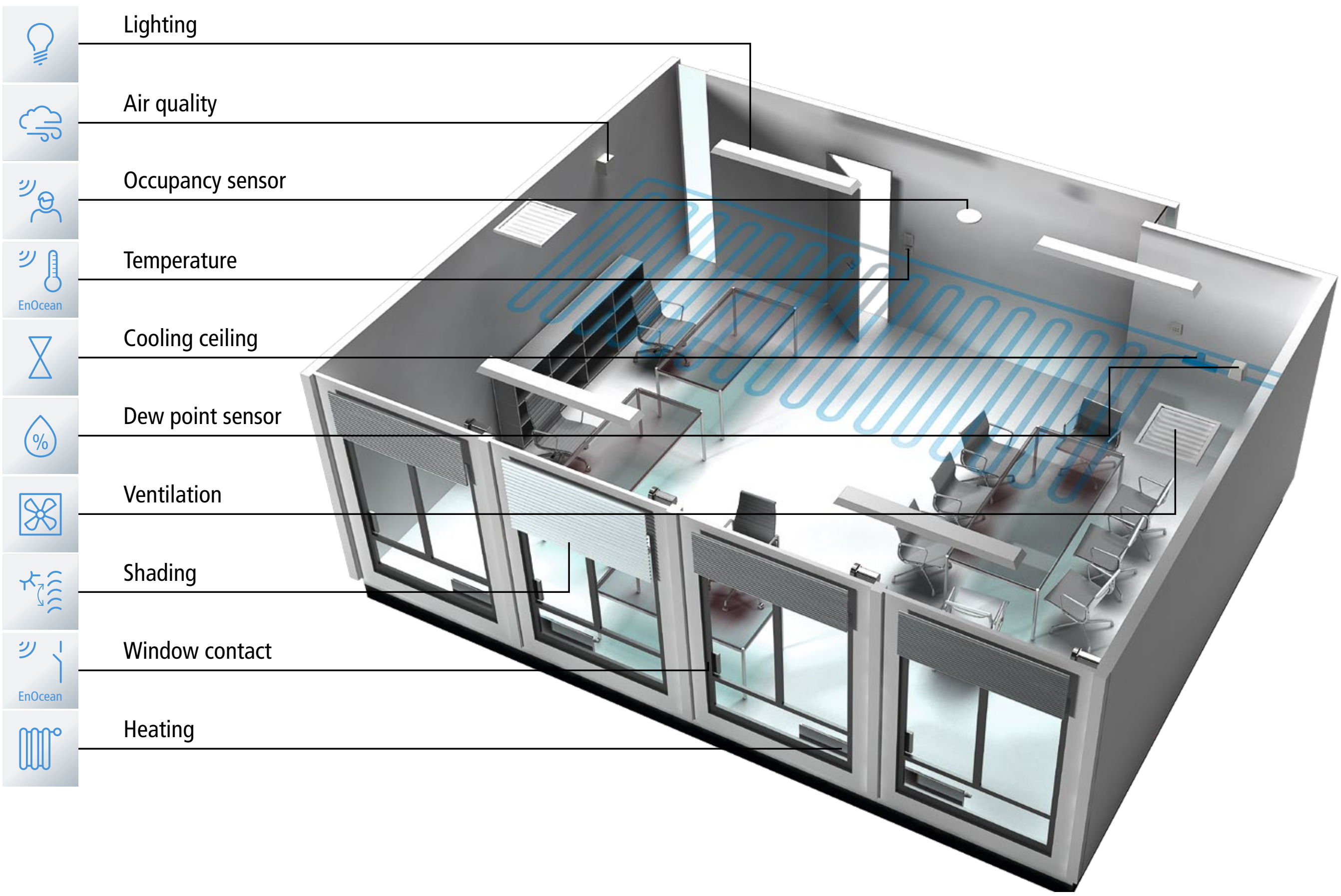
For ventilation, the office is connected to an air-conditioning installation. Volume flow is variable. The open state of the window is captured via a digital input; so too is the dew point sensor on the cooling ceiling.

Heating/cooling function
To minimise energy use for room heating and cooling, the desired room temperature is determined via a scheduler-dependent energy level selector (see fig. 1, page 30, and fig. 2, page 31). In the case of long absences, e.g. during shut-down periods, the office is switched to "Protection", the lowest energy level, to prevent damage caused by frost or overheating. For brief absences, e.g. at night or on weekends, the office is set to "Economy" mode. Only at the start of core working time is the energy level raised to the level "Pre-Comfort". The room temperature is now almost up to the comfort target value. Only when persons are detected in the room is "Comfort" mode activated and the appropriate set value reached in a short time.

The system switches from "Economy" to "Pre-Comfort" mode as late as possible via the energy level selector with start optimisation. The optimum activation time is calculated by the building automation system.

The opening of the window is monitored by a window contact. If the window is open, the system automatically switches to the "Protection" energy level. This automatically stops unnecessary energy consumption due to a window being opened.

The room temperature set values for all four energy levels are provided by the room climate function set value calculation for heating and cooling.



The "Function Selection" regulates the controller for heating and cooling and compares the current room temperature against the set value. If the current value is lower than the target value for the energy level "Comfort" heating, the heating controller is activated. If the current room temperature is higher than the set value for the energy level "Comfort" cooling, the cooling controller is activated. Simultaneous heating and cooling is not possible.

Ventilation

In summer, natural cooling at night helps reduce energy consumption: The night cooling program switches on the room ventilation system and ventilates the offices using cool external air. This removes heat from the building at night so that less energy is required to cool the room the following day. For electrically operated windows, these can also be used for automatic night cooling in summer.

Load optimisation

Communication between systems for automation of energy centres and systems for the generation and distribution of heating and cooling water enables needs-based adjustment of the flow temperatures. This allows transfer losses to be minimised and the overall effectiveness of the systems to be increased.

Air quality regulation

Depending on the measured air quality, the volume flow controller is used to introduce more or less fresh air into the room. If the air quality is good, air intake is reduced to a minimum volume flow. The central air conditioning unit for ventilation automatically adjusts the level of ventilation based on the data communicated between the room automation system and the primary systems. This reduces the energy consumption of the fans by up to 45 %. In the event of zero occupancy, the volume flow is reduced to a minimum.

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Shading: thermo-automatic control and shading correction

Constant light control

If a minimum light strength in the room is not reached but the room is occupied, the constant light control function switches on automatically. Conversely, if the amount of external light increases, the proportion of artificial light automatically reduces or is switched off once a suitable lighting strength is reached. If the occupancy detector identifies that the room is empty, the constant light control function switches itself off on a time-delay basis.

Shading

Control of solar shading is integrated directly into the room automation system. The "thermo-automatic" function supports the heating and cooling function of the room if it is not occupied. To benefit from sun light in winter, solar shading is raised to help heat the space using the sun's rays. In summer, the solar shading is automatically activated to reduce the energy yield from the sun and to assist cooling.

If the room is occupied and the sun is shining in strongly, the solar shading is automatically activated. The louvre adjustment optimises the angle of the louvre according to the position of the sun. The blades are positioned in such a way as to prevent blinding from direct sunlight while keeping the need for artificial lighting to a minimum in order to reduce energy consumption.

The shading correction function calculates the shadow movement on the facades of the building, depending on the position of the sun, the facade orientation and the position and coordinates of the surrounding buildings that provide shade. This prevents unnecessary activation of the solar shading and increased energy consumption due to the use of artificial light within the building.