Application Note DK9222-0310-0016

Building Automation

Keywords
Energy efficiency
Brightness adjustment
Lighting
TwinCAT Library
Building Automation
Daylight-dependent light control
Constant light regulation
Light control strategies
Brightness control
Universal dimmer
KL2751
KL2761

Light control scenarios for the optimisation of energy efficiency with dimmer terminal and TwinCAT Library

This application example describes four scenarios for energy saving in buildings, using the TwinCAT PLC Building Automation basic library and the dimmer terminal KL2751 or KL2761. The fieldbus-neutral universal dimmer in the form of a Bus Terminal facilitates the decentralisation within building automation and permits operation via standard light switches or Control Panels.

The KL2751 and KL2761 Bus Terminals are universal dimmers with linearised characteristic for the even brightness adjustment of lighting elements. Capacitive, inductive and ohmic loads can be connected to the 1-channel universal dimmer terminal. Since the terminal is capable of both types of phase control, it selects the appropriate control profile depending on the connected load (KL2751 – 300 VA, KL2761 – 600 VA). Furthermore, the terminal can be integrated into any control environment via Bus Couplers and is thus a network-capable universal dimmer that is not based on the DMX protocol standard normally used for professional lighting.

Advantages of the KL2751/KL2761 dimmer terminal

The bus-independence of the dimmer terminal offers advantages in many aspects:

– Simple decentralisation:
  Frequently, there are already infrastructures in existence that can be used as a basis or can be extended without problem. The information points (ISP) can be structured according to a star or line topology; this way, the dimmer terminal does not necessarily have to be placed in the immediate vicinity of the central controller. For example, a Beckhoff Embedded PC (e.g. a CXxxxx) with several BKxxxx Bus Couplers can take over the floor control; the dimmer terminal is connected to one of the Bus Couplers. A decentralised controller reduces material costs (standard Ethernet cables in the case of an Ethernet

structure) and permits direct wiring to the I/Os.

– Simple installation:
  As opposed to conventional building systems, the use of the dimmer terminal does not require a lower-level sub-bus outside the terminal strand. A standard Ethernet cable can be used for wiring the controllers, whereas a standard installation cable (NYM) is used to wire from the terminal.
– Operating independence:
  Both conventional switches (without bus connection) and Control Panels can be used for operation. When selecting the operating elements, therefore, users are not reliant on their systems also supporting the selected components. Furthermore, the use of standard switches minimises the costs.
– Low space requirement:
  As opposed to the previous solution with a DIN rail dimmer and an analogue input terminal, the dimmer terminal offers all of the required functions in a width of just 12 mm.
– Ethernet capability:
  According to the prevailing know-how and the infrastructure, the terminal can be integrated into any existing control environment via the appropriate Bus Coupler. Therefore, the system does not need to be changed in case of an existing I/O infrastructure with EIB or LON components.

Energy-saving potential in lighting

The use of building control increases the energy efficiency of buildings to the highest degree. To this end, all functions of the building are supervised and regulated by a central controller. The individual functions can be automated as a whole or also separately. Below, we will deal with the energy-saving potential offered by lighting controllers, which can be implemented with a few system components from the Building Automation range and TwinCAT automation software.

TwinCAT PLC Building Automation library basic

The TwinCAT PLC Building Automation library basic is an IEC 61131-3 software library, which provides function blocks for the execution of basic functions in the field of building automation. Important functions for the field of building automation can be programmed with this library: lighting control, stairwell lighting, light dimmer with one or two switches, peak load limiter for energy optimisation, blind controller, signalling contact, distinction between single and double as well as between short and long switch actuation, threshold switch, filter for the smoothing of analogue input signals, scaling functions for the conversion of raw values to measured values as well as functions for the conversion of temperatures (Kelvin, Celsius, Reaumur, Fahrenheit).

Various TwinCAT PLC libraries can be used for the automation of buildings; this application example covers the part of the TwinCAT PLC Library Building Automation Basic that is relevant for the lighting. The prefabricated function blocks below are used in the following four control scenarios for automated lighting:

Application Note DK9222-0310-0016

Building Automation

FB_Dimmer1Switch	Light dimmer using a single switch
FB_Light	Lighting control
FB_LightControl	Daylight-dependent light control
FB_ConstantLightControlEco	Constant light regulation
FB_Sequencer	Light sequence block
FB_StairwellLight	Stairwell lighting circuit
FB_StairwellDimmer	Stairwell dimmer
FB_WeeklyTimeSwitch	Weekly timer
FB_VenetianBlind	Blind controller

Tab. 1 Required function blocks from the TwinCAT PLC Building Automation library

Lighting control = energy saving

Without a lighting controller, the lighting in a commercially used building, e.g. an office building or a school, is switched on in the morning and switched off in the evening. Since artificial light is used throughout the day, 100 % of the energy costs result here. The following lighting strategies make extensive energy savings possible with the employment of automated lighting:

A Central switching off

B Time-dependent lighting

C Daylight-dependent lighting (daylight-dependent light control/constant light regulation)

D Presence-oriented lighting

Application Note DK9222-0310-0016

Building Automation

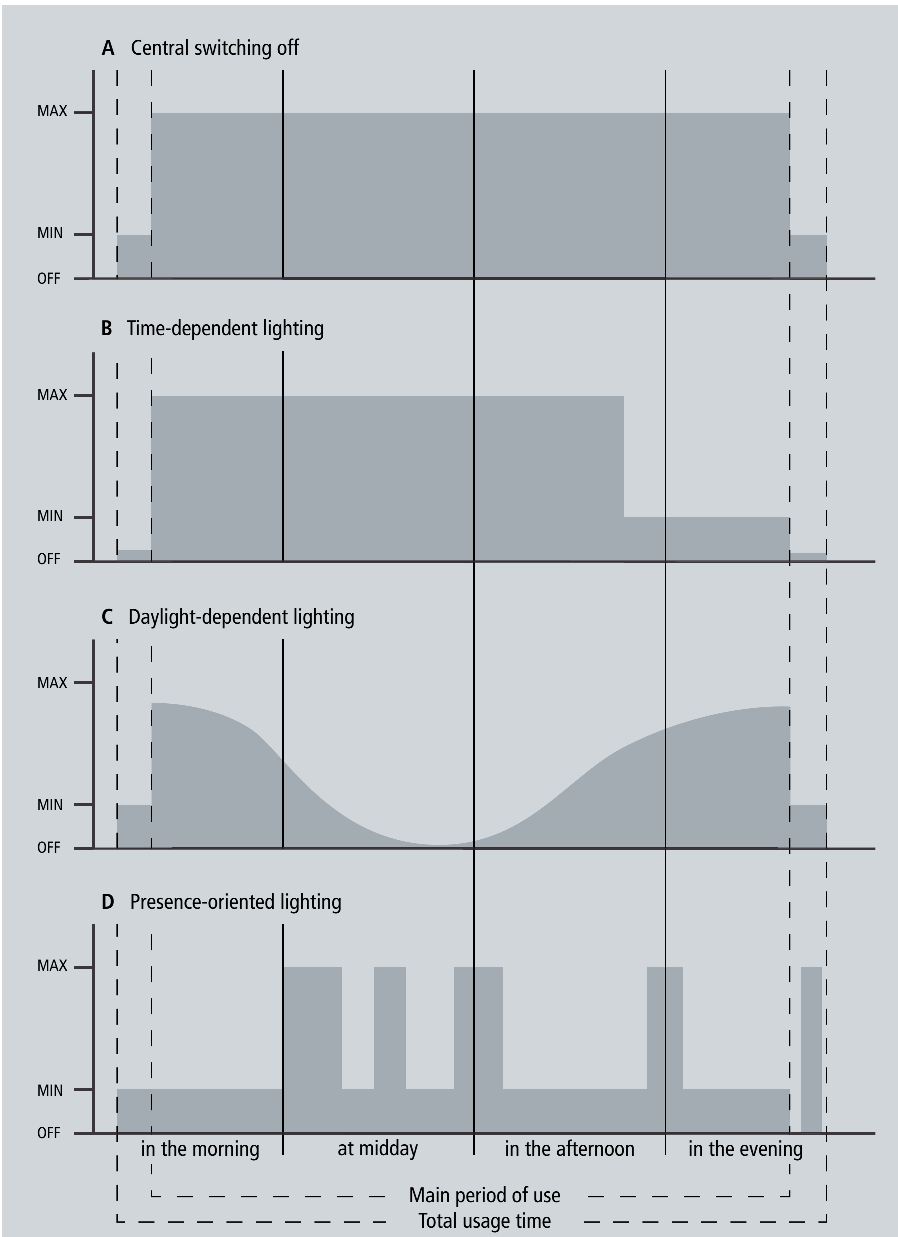

Fig. 1 Overview of light control strategies for the reduction of energy consumption

By the use of suitable light control strategies, integrated into an integral building automation, significant energy savings can be achieved while at the same time increasing comfort and well-being inside the building. The energy saving can be maximised by the combination of different strategies.

Application Note DK9222-0310-0016
Building Automation

A Central switching off

Central switching off of the lighting or central dimming to a minimum lighting level takes place before and after the main period of use of the building.

Function blocks: **FB_Light, FB_Dimmer1Switch, FB_Sequencer, FB_WeeklyTimeSwitch**

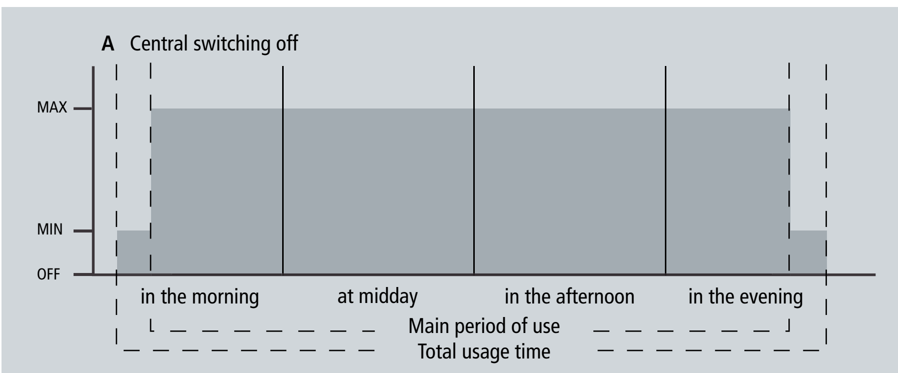

Fig. 2 Saving of energy by central switching off

B Time-dependent light control

If the lighting for individual rooms is switched manually, switching off is frequently forgotten once the last person has left the room. Here, the saving potential is achieved in the time-dependent control of the light, in which the light is switched either

- relative to an event, or
- absolutely at a time or a date.

A mode that is orientated **relative to an event** is typically suitable for stairwells and less frequented rooms: a switch activates a pre-programmed timer upon whose expiry the light is switched off. The duration can be adapted to the usage profile of the room. For comfort-orientated rooms, the light can be dimmed discretely in order to signal imminent switching off, which can be delayed by pressing the switch again.

Required function blocks: **FB_StairwellLight, FB_StairwellDimmer, FB_Light**

Application Note DK9222-0310-0016

Building Automation

A **time-dependent mode** switches the lighting off automatically at a pre-determined time. In this case, the switchover can also be indicated by a dim phase, so that the user has the possibility to delay the switch-off by pressing a switch.
Required function blocks: **FB_Light, FB_Dimmer1Switch, FB_WeeklyTimeSwitch, FB_StairwellLight, FB_StairwellDimmer**

Energy costs can be lowered particularly in the off-peak times by the employment of a time-dependent light controller; see also area B in fig. 3.

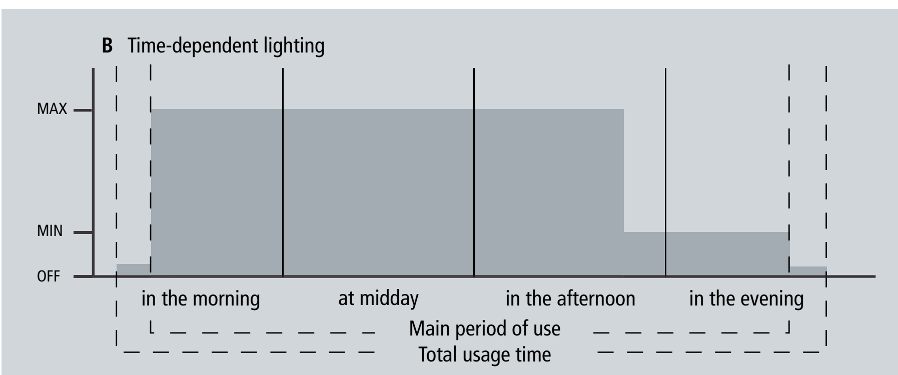

Fig. 3 Energy saving by means of central switching off and time-dependent lighting

C Daylight-dependent lighting

Two concepts can be used in order to control the brightness of the room in relation to the incidence of daylight:

– daylight-dependent light control
– constant light regulation

The **daylight-dependent light controller** uses an external brightness sensor on the outside of the building and influences the room brightness according to preset values. If shading is used, the position should also be queried in addition to the general query (shading active), in order to optimally adjust the lighting intensity.
Required function blocks: **FB_LightControl, FB_VenetianBlind**

The **constant light regulation** uses brightness sensors distributed in the room and maintains the light intensity at a preset value by switching on sources of artificial light at a reduced light intensity as required. In order to optimally exploit the incident daylight in the case of constant light regulation, it is recommended to use controllable blinds that not only darken, but also let dimmed daylight into the room. This measure allows energy costs to be reduced on very sunny days, since the dimming effect prevents the room from heating up (reduced operation of the cooling system).
Required function blocks: **FB_ConstantLightControlEco, FB_WeeklyTimeSwitch, FB_Dimmer1Switch**

Application Note DK9222-0310-0016

Building Automation

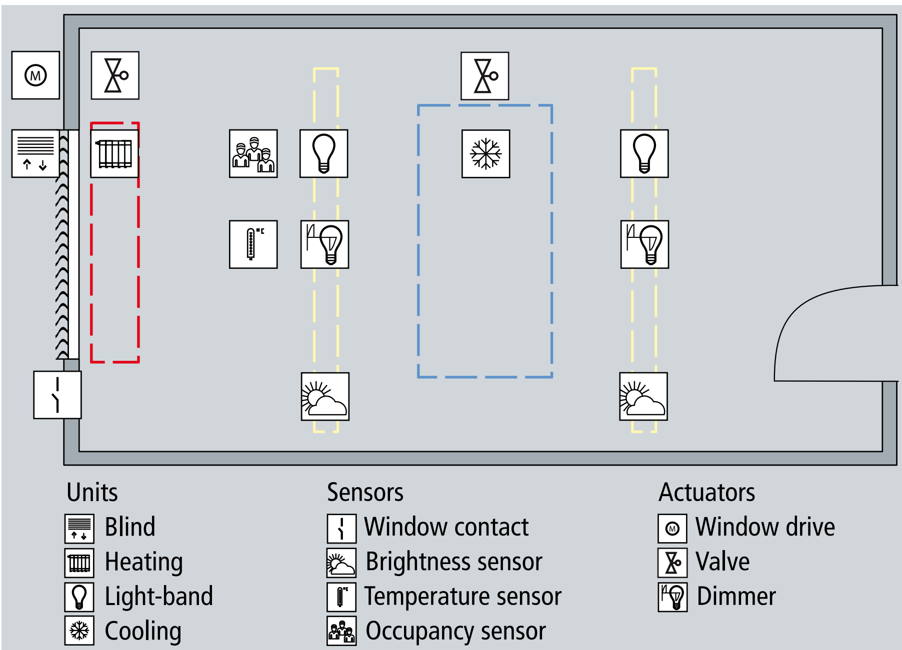

Fig. 4 Units, sensors and actuators for the control of an office

As shown in fig. 4, this light control strategy requires the interaction of the actuators and sensors located in the room in order to control the room. The incident daylight from the window side provides – depending on the room depth – for the standardised light intensity of 500 lx on work surfaces. The constant light regulator dims the light-bands, so that artificial light supplies the missing light portion required to reach the target light intensity. Ideally, each light-band has its own brightness sensor. This way, zone 1 directly by the window can be switched off on very bright days, if the amount of incident light is sufficient. Zone 2, located further inside the room, is dimmed depending on the incidence of light.

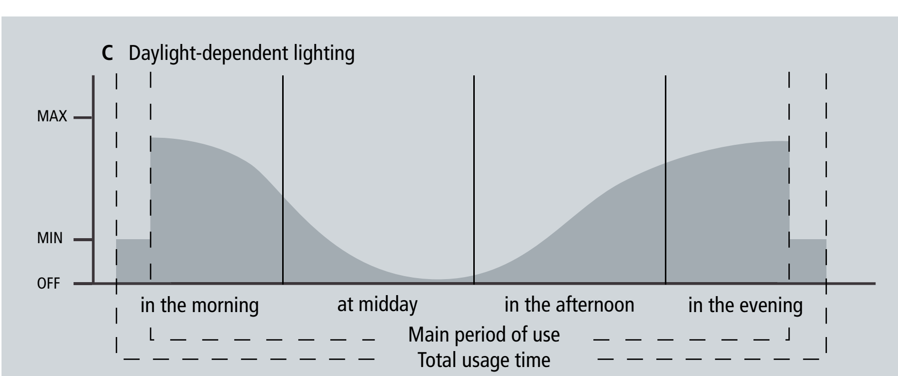

Fig. 5 Energy saving by means of central switching off, time-dependent and daylight-dependent lighting

Application Note DK9222-0310-0016
Building Automation

D Presence-oriented lighting

The employment of a presence-dependent daylight controller for energy cost reduction is particularly useful for rooms that are not constantly in use, such as corridors or meeting rooms (fig. 6). If meeting rooms are only partly used over the course of the day, presence sensors switch the room functions automatically from the comfort to the standby or energy-saving mode. A presence-dependent light control significantly reduces the energy costs for corridors outside the main period of use. In addition, a mode can be selected in the main period of use that reduces the corridor lighting to an adjustable minimum level if nobody is in the corridor. Apart from manual control, time-controlled switching can effectively contribute to a reduction in the energy costs. The presence sensor is implemented by a digital input.
Required function blocks: **FB_Light, FB_WeeklyTimeSwitch, FB_Dimmer1Switch**

This results in the optimum saving of energy while at the same time prolonging the service life of the lamps. If the corridor lighting is presence-dependent, then it supplies the correct light whenever it is needed, thus consuming a minimum amount of energy. In comfort-orientated rooms, switching off can be dispensed with and dimming to a minimum lighting level can be selected instead. This control principle can also be applied to outdoor and pathway lighting in order to always switch the lighting on punctually depending on brightness, motion and time.

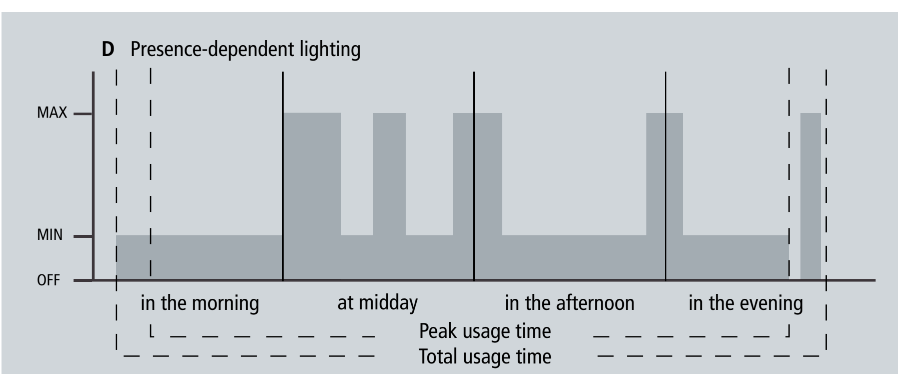

Fig. 6 Energy saving by means of presence-orientated lighting

Application Note DK9222-0310-0016

Building Automation

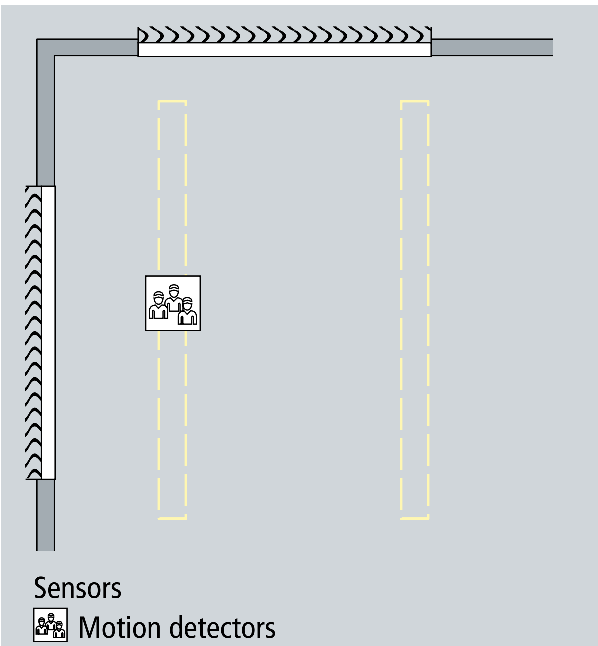

Fig. 7 Use of a motion detector in the combination of presence-dependent and daylight-dependent lighting

Motion detector

As opposed to motion detectors, presence sensors react even in very bright light; this way, the use of inexpensive motion detectors instead of presence sensors is not always possible. If daylight-dependent and presence-orientated lighting are combined, then a motion detector can be used in order to reduce energy costs. The motion detector located directly underneath the light-band (fig. 7) is active only if the brightness falls below the preset level. Then, if a movement is detected by the sensor, the light-band can be dimmed either to a fixed value or according to the specification of the external brightness sensor. This combination achieves high energy savings, particularly in less frequented rooms with large window areas, by switching off/dimming the light zone close to the windows.

– 1-channel universal dimmer terminal, 230 V AC, 300 VA (W) **www.beckhoff.com/KL2751**
– 1-channel universal dimmer terminal, 230 V AC, 600 VA (W) **www.beckhoff.com/KL2761**
– Optional TwinCAT software packages Building Automation
  www.beckhoff.com/english/twincat/plc_libraries_building_automation.htm
– The modular automation components for building automation **www.beckhoff.com/building**

Application Note DK9222-0310-0016

Building Automation