Application Note DK9222-0810-0031

I/O, Building Automation

DALI – digital standard for room-related light management

This application example from the 'Building Automation Sub-bus Systems' series covers the basic principles for the integration of the KL6811 DALI Master Terminal for the Beckhoff Bus terminal system. DALI is an easy-to-install interface that enables the fully digital connection of light fixtures and comparable devices within building automation applications. As a standardized interface for up to 64 field devices on one terminal that can be connected via unshielded, 2-conductor, small gauge installation cables, the user benefits from simple, functional light management that can be connected via gateways to a building automation system. Changes of light scenes are implemented with DALI via the software; therefore, DALI is less expensive and more flexible in terms of cabling in comparison with the 1 – 10 V technology. The terminal and the DALI strand can be parameterized alternatively via the KS2000 configuration software (for Bus Terminal Controllers and Bus Couplers) or via TwinCAT automation software (for PC-based systems).

1.   DALI

The **D**igital **A**ddressable **L**ighting **I**nterface (DALI) is an interface definition in building automation for the transmission of control signals for lighting devices. To this end, DALI ballasts are wired in parallel and linked with one another via the controller. Up to 64 operating devices can be addressed individually and can be divided freely into 16 groups of lights and 16 light scenes. In addition to switching the lighting devices, the status and individual parameters (dimming values, etc.) can also be queried.

As opposed to the building automation technology, DALI is specially conceived for room-related light management and, due to this specialization, lowers integration costs and reduces the installation expenditure and the costs when making changes.

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DALI has simple commissioning procedures that are automated as much as possible and it can be integrated in the building automation system via gateways if required.
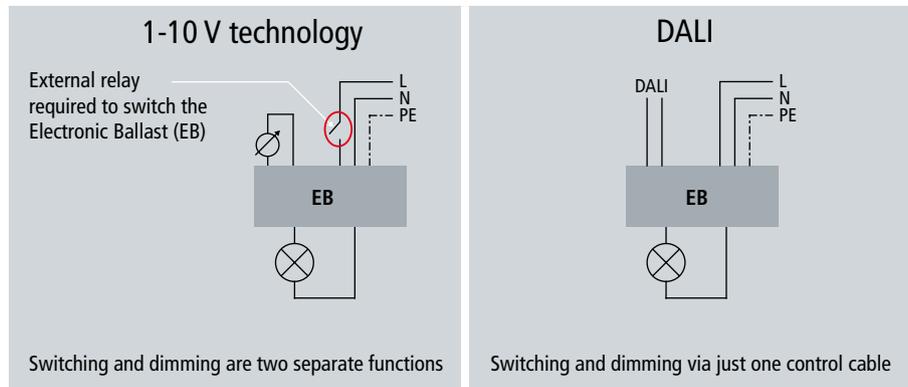

Fig. 1   Difference between conventional serial wiring and parallel wiring

2.   Origin

DALI, often designated as a bus system, is the result of an effort to standardize digital interfaces on electronic ballasts. The unified standard allows the manufacturers of lighting components to implement complex lighting tasks easily and conveniently. Unlike the conventional analog 1 – 10 V technology, the connected devices are switched directly, so that external relay contacts are not necessary (see fig. 1). Since DALI communication is digitized, the DALI controller, as the central control unit, can address the individual devices directly and query and administer diagnostic functions and status feedback from individual devices. The internationally established standard guarantees the interchangeability of ballasts from different manufacturers.

3.   Typical field devices

The DALI interface is described in the IEC 62386 standard. The areas of the standard correspond in each case to a connectable type of device:

– Part 201: Fluorescent lamps (device type 0)
– Part 202: Emergency lighting (device type 1)
– Part 203: HID lamps (device type 2) (HID = **H**igh **I**ntensity **D**ischarge)
– Part 204: Low voltage halogen lamps (device type 3)
– Part 205: Dimming of general-purpose lamps (device type 4)
– Part 206: Conversion of digital signals to DC voltage signals (device type 5)
– Part 207: LED modules (device type 6)
– Part 208: Switching function (device type 7)
– Part 209: Colour control (device type 8)

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The KL6811 DALI Master Terminal from Beckhoff currently supports areas 201, 202, 203 and 209.

4.   Master versions

A master and a corresponding power supply to generate the DALI control voltage are required for each DALI strand. The devices are not usually supplied with power via the DALI master. Up to 64 addresses can be managed per master, which corresponds in practice to 64 devices. However, DALI is a single master system; therefore, care needs to be taken when using components from different manufacturers that two masters are not inadvertently installed in one strand.

5.   Topologies

Star, tree or mixed topologies can be used when constructing DALI lines. However, 64 individual addresses can be assigned (64 devices). These addresses can be assigned entirely independently of one another to 16 group addresses (light groups). In addition, 16 lighting values can be stored, which correspond to 16 different light scenes.
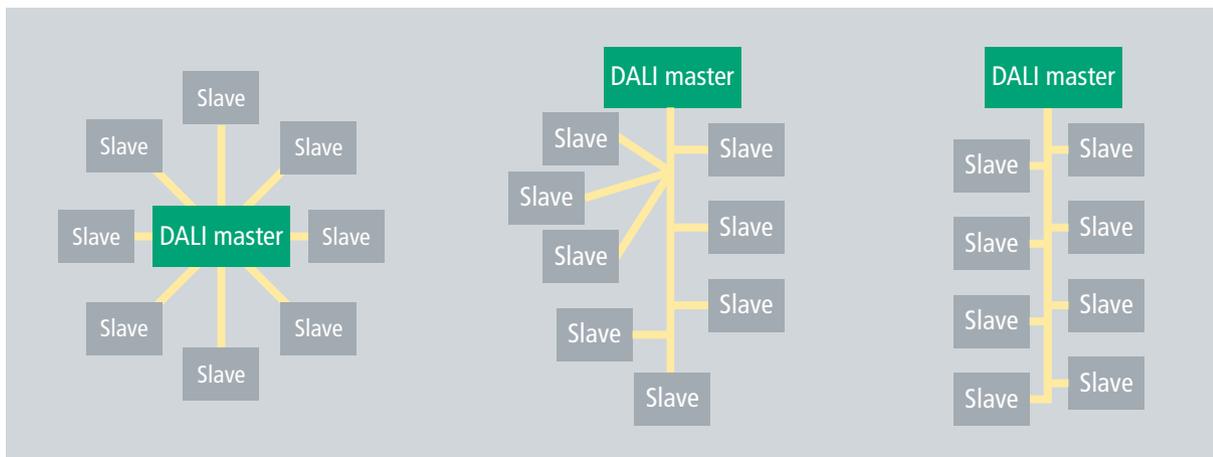

Fig. 2   DALI topologies

5.1   Laying system, cross-section and cable lengths

DALI topologies can be constructed in principle using standard installation cable. A 5-core cable is recommended, since control cores (DALI+, DALI-) and supply cores (phase, neutral and PE) can be fed in one cable. The polarity can be neglected for the DALI control cores even though they are marked DALI+ and DALI-; furthermore, end resistors are not necessary. The insulation of the digital interface conforms to EN 60928 (basic insulation), thus SELV is not ensured! The length of the entire line depends on the selected cable diameter as well as the type and number of connected slaves. The maximum cable length must not exceed 300 m. In addition, the voltage drop over the entire length of the line may not exceed 2 V DC!

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Recommended cross-sections for standard installation cable:	
Cable length	min. cable cross-section (AGW)
up to 100 m (325 ft)	0.5 mm² (#20)
100…150 m (325…492 ft)	0.75 mm² (#18)
150…300 m (492…984 ft)	1.5 mm² (#16) recommended

Table 1   Relationship between cable cross-section and cable length
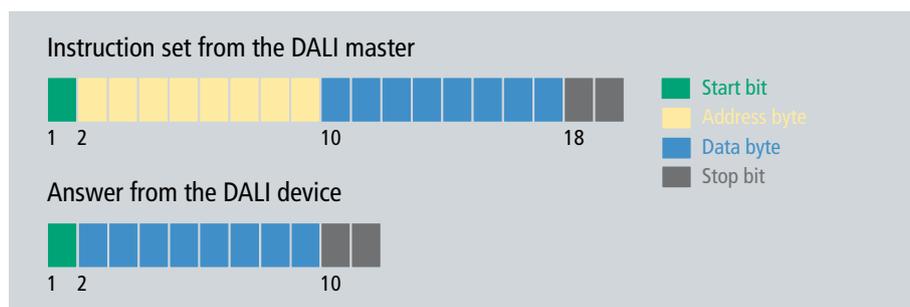
6.   Communication: short description

Fig. 3   Structure of a DALI telegram

The DALI protocol consists of 19 bits, thus allowing the individual addressability of 64 lights, status feedback (set dimming value, lamp test) as well as a large number of adjustable parameters such as fade time, fade rate etc. The transmission rate is 1,200 Baud which, in combination with the low voltage level of the DALI signals of maximum 22.4 V DC, ensures good electromagnetic compatibility (EMC). All devices in a DALI system must conform to the following European standards: EN 55015, EN 61547, EN 61000-3-2, EN 63000-3-3.
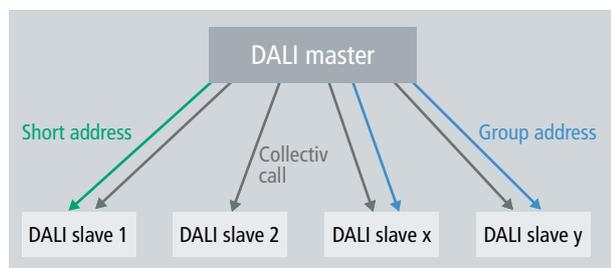

Fig. 4   Addressing the DALI devices via short address, group address or collective call

7.   Power supply

The DALI system voltage ranges from 9.5 to 22.4 V DC. The devices are usually supplied with power via 230 V AC, so that a standard 5-core installation cable can be used both as a data cable and for supplying power (see fig. 5).

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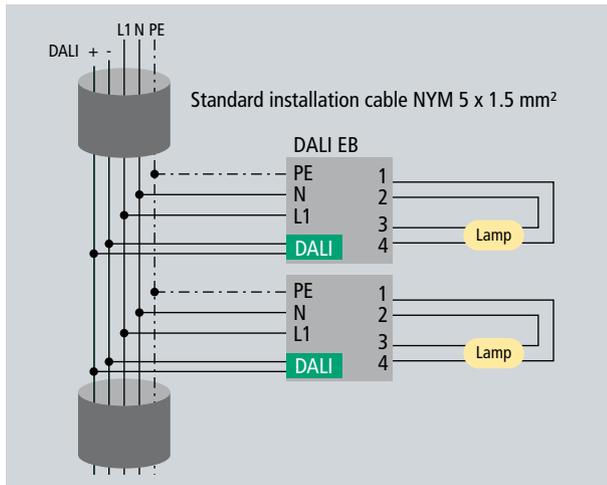
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Fig. 5   Power supply to the DALI devices

8.   KL6811 DALI Master Bus Terminal with integrated power supply unit

The KL6811 allows the connection of up to 64 DALI slaves and is extremely well-suited for the control of electronic ballasts. Lighting systems can be switched and dimmed just by using simple, standard buttons, since the signals are linked within the controller. The KL6811 from Beckhoff is fieldbus-independent and can also be used as a DSI master. DSI is the precursor of DALI and is based on a serial transmission method.

No further components are necessary for the operation of the DALI slaves, since the KL6811 contains an integrated 24 V DC power supply unit with electrically isolated output voltage (see fig. 6). The power supply unit and the DALI voltage are connected inside the terminal, so that only a cable with two cores (DALI+, DALI-) needs to be led from the terminal. The integrated power supply unit is designed for 64 devices with a current consumption of 2 mA each and can also be switched off if necessary, if the DALI devices are supplied from an external power supply unit.

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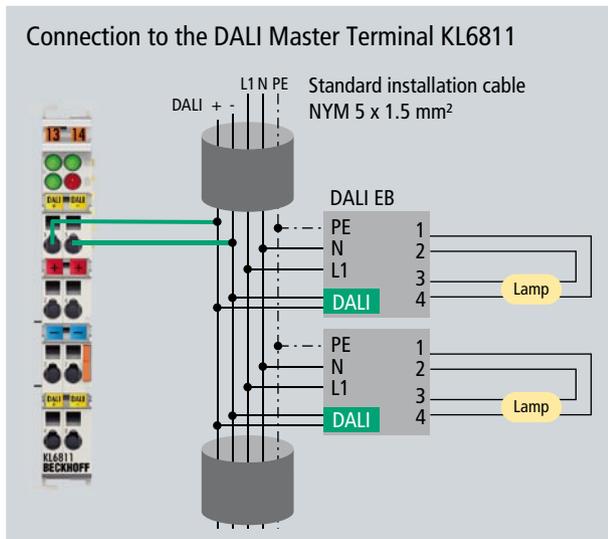
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Fig. 6   Power supply via the KL6811 DALI Master Terminal

A further special feature of the terminal is the overvoltage power-off at the contacts for the DALI control line: If 230 V AC are inadvertently connected to the DALI terminal points, then the terminal is not destroyed, but switches itself off instead.

9.   Parameterization

The KL6811 DALI Master Terminal from Beckhoff can be parameterized using both the TwinCAT automation software, in the case of PC-based systems, and the KS2000 parameterization software in the case of Bus Terminals. The TwinCAT supplement 'Building Automation Framework' is also suitable for PC-based systems with the emphasis on DALI connection.

As the controller, the KL6811 Bus Terminal sends only control sequences such as ON, OFF, UP, DOWN, GO TO SCENE, ADD TO GROUP, etc. via the interface to a connected ballast, which then carries out the commands independently. Between the terminal and the ballast, communication takes place in which feedback messages about lamp defects, dimming values, error messages, etc. are queried.

9.1   Integration with the KS2000 configuration software

If Bus Terminals are used, the KL6811 can be parameterized simply via any service PC using the KS2000 configuration software. If connected by means of an RS232 interface or via the fieldbus directly to the Bus Coupler, the individual DALI devices can be addressed and configured in the graphic menu interface of the KS2000 software (see fig. 7). Organization into light groups and light scenes is accomplished on the basis of selection menus and can be managed clearly in tables.

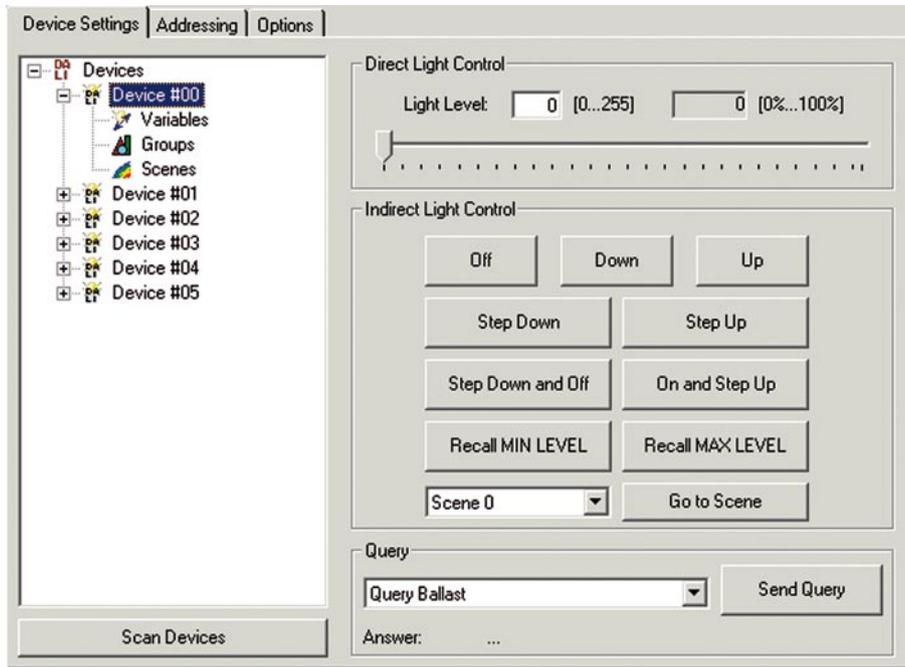**Application Note DK9222-0810-0031**

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Fig. 7   Configuration of the DALI devices via the graphic menu interface of the KS2000 software

9.2   Integration with TwinCAT

If Beckhoff control technology is used, then TwinCAT supports the KL6811 with its own library:
TwinCAT PLC Library DALI.

The library offers function blocks for the configuration and programming of the KL6811 DALI Master Terminal and can be used both on Bus Terminal controllers and on a PC or a CX Embedded PC. Among other things, it contains function blocks for the following functions:

– Function blocks for changing the lamp power (dimming)
– Function blocks for changing and querying various parameters of a DALI slave
– Function blocks for assigning addresses to individual DALI slaves
– Function blocks for configuring DALI groups and DALI scenes

However, all DALI commands can be represented by a PLC block. When TwinCAT is used, the program for controlling the DALI field device is loaded from the PLC and thus cannot be lost.

A further possibility for integrating the KL6811 DALI Master Terminal in TwinCAT is the **TwinCAT Building Automation Framework**: This TwinCAT supplement is extremely well-suited for lighting technology and supports the user or system integrator conveniently both in the development and in the commissioning of corresponding DALI applications. The engineering and commissioning of buildings can be simplified considerably with the help of the tool. System integrators, operators and building users can carry out new functions, changes of scenes or the assignment of sensors/actuators with just a few clicks.

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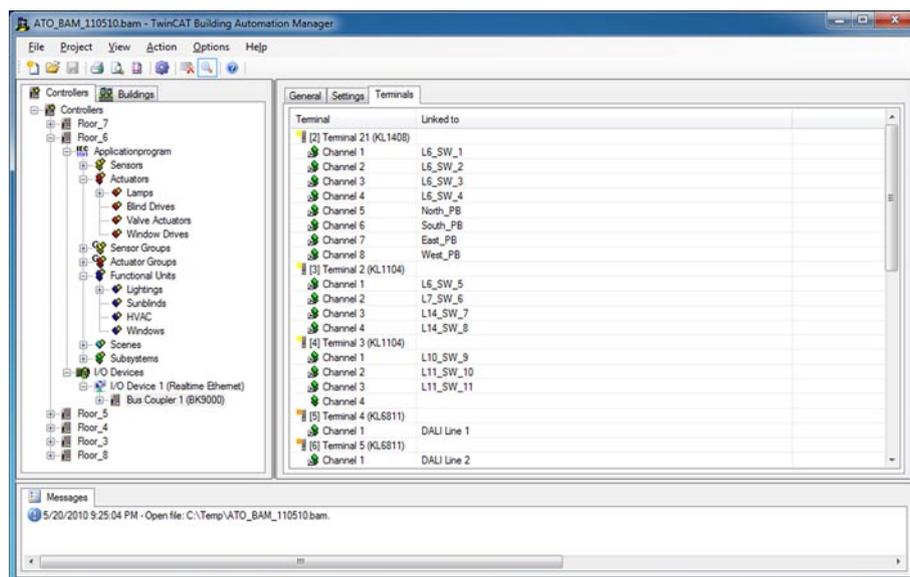I/O, Building Automation

Fig. 8   View of the Building Automation Manager

In the Building Automation Manager, as the configuration tool within the framework, the existing components (Industrial PCs, Embedded PCs, Bus Terminals and data points) are registered and assigned to the appropriate functions. The state of all sensors and actuators can be monitored and controlled in the TwinCAT Building Automation Manager. In addition, the actuators can be switched manually, for example, for commissioning purposes. With the aid of the configuration wizard, the user can simply create links between actuators and sensors. From this information the configuration program generates the parameters, based on the Building Automation Framework PLC Library, that contain the most important functions for the building automation.

9.3   Integration into higher level systems

For integration into the building automation system, the DALI terminal can be connected to a master computer, for example via an Embedded PC with an Ethernet connection. In this way, the DALI field device can be switched in relation to the various parameters of the building control system. Errors and status messages can thus be passed through from the field level to the command level.

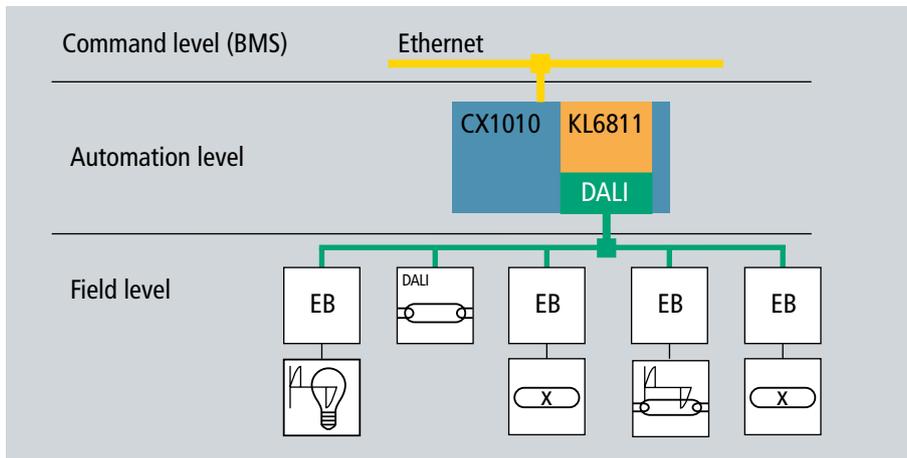**Application Note DK9222-0810-0031**

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Fig. 9   Integration of lighting elements into the building automation system

10.   Practical example

With the implementation of intelligent lighting control for a floor of a building, the advantages of DALI in comparison with 1–10 V technology become clear.

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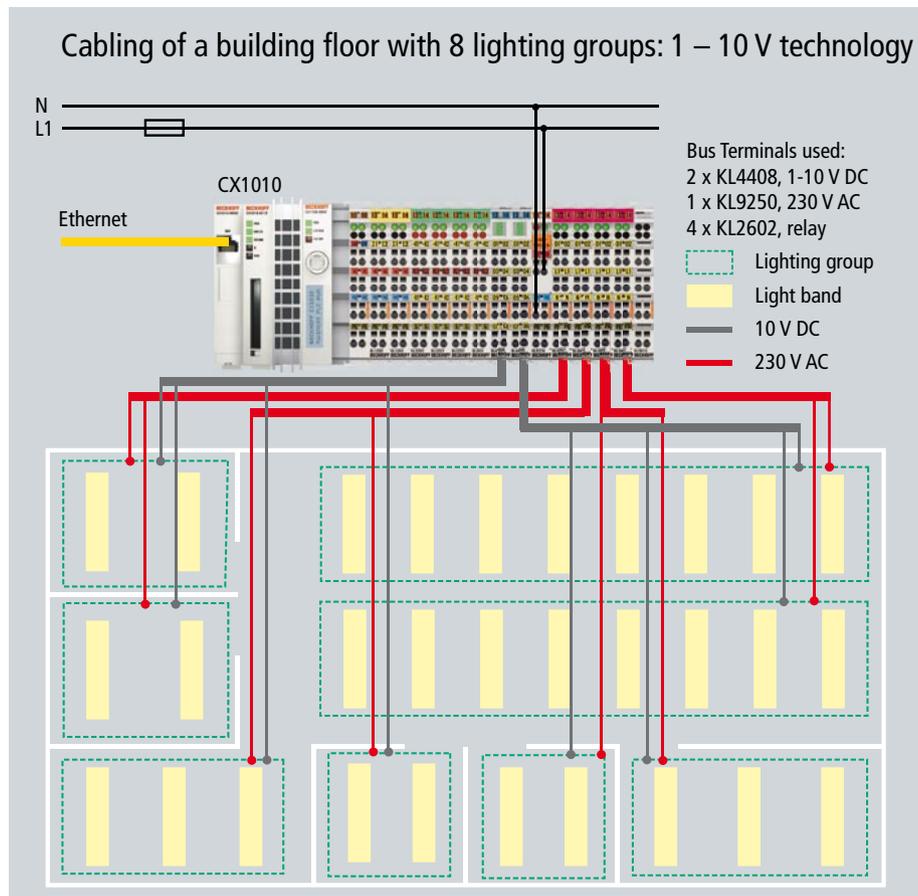
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Cabling of a building floor with 8 lighting groups: 1 – 10 V technology

N
L1

CX1010

Ethernet

Bus Terminals used:
2 x KL4408, 1-10 V DC
1 x KL9250, 230 V AC
4 x KL2602, relay

- - - - Lighting group
Light band
10 V DC
230 V AC

Fig. 10   Cabling expenditure and use of materials with 1 – 10 V technology

The cabling expenditure is significantly reduced, since not every element has to be provided with a separate power supply and a control cable. The use of materials is also reduced, since external relays for switching the ballasts can be eliminated and the control line can be laid as a line instead of a star-shaped topology.

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Cabling of a building floor with 8 lighting groups: DALI system

N
L1

CX1010

Ethernet

Bus Terminals used:
1 x KL6811, DALI

- - - Lighting group
Light band
DALI
230 V AC

Fig. 11   Simplified cabling with DALI

Apart from the advantages with regard to the cabling, there are further advantages in relation to the flexibility over the life cycle of a building. Changes in the room layout or scene allocations can be adapted simply via software. Under certain circumstances these changes can be made locally via the network and no technician needs to be on site.

– DALI/DSI master and power supply terminal **www.beckhoff.com/KL6811**
– TwinCAT PLC library DALI
    www.beckhoff.com/english/twincat/twincat_plc_building_automation_dali.htm
– TwinCAT Building Automation Framework
    www.beckhoff.com/english/twincat/twincat_building_automation_framework.htm
– Beckhoff Building Automation **www.beckhoff.com/building**
– Configuration software KS2000
    www.beckhoff.com/english/fieldbus_components_accessories/ks2000.htm
– TwinCAT Supplements Building Automation

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www.beckhoff.com/english/twincat/twincat_supplements_building_automation.htm

– TwinCAT **www.beckhoff.com/TwinCAT**