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I/O, Building Automation

Keywords
KL6301
EIB
Line coupler
KNX
ETS
Sensor/actuator
Building Automation
Group filter
Group address
Physical address

Integration of EIB lines into a PC-based building automation system

This application example from the series 'Sub-bus systems in building automation' describes how an EIB line can be integrated into the PC-based building automation system via the Beckhoff KL6301 EIB Bus Terminal. EIB is a local two-wire bus system for the connection of sensors and actuators. Its main area of use is in building automation, since EIB is extremely well suited for implementation in various trades.

1. EIB – European Installation Bus

EIB is a P2P bus system for the automation of private houses and functional buildings and significantly increases the utility value of a building due to the ability to network the individual trades. Linked by a two-wire bus, the connected actuators and sensors exchange data with one another. Furthermore, couplers (line, area or segment couplers) perform structural functions as amplifiers, routers, etc. Powerline and wireless transmission are further possible means of transmission.

The association for the support and distribution of the bus system was originally the 'EIBA' (European Installation Bus Association); its successor organization since 1999 is the 'KNX Association'.

2. Typical field devices

All field devices in every shape and size of installation technology exist in EIB:

- Surface-mounted
- Installation
- Flush-mounted
- DIN rail mounting

Devices from different manufacturers are usually compatible, so that the range of available EIB devices is very extensive:

- Lighting controller
- Shading controller
- Heating and ventilation controller
- Single room temperature controller
- Energy and load management
- Display, monitoring, indication and operation
- Communication with other systems

EIB networks the individual trades to form a uniform system, thus allowing additional functions. Technology, planning and execution are merging thanks to this trade-spanning system.

3. Master versions

EIB is a system with local intelligence and it therefore has no master as a central control unit. Every device is authorized to send and receive telegrams.

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4. Topology

EIB is divided into 15 areas, each with 15 lines and in turn 64 devices per line. For an example in using these numbers to locate individual devices, the physical address 8.7.233 designates device 233 in area 8, line 7. The three lines 12 to 15 are reserved for future use, so in the future, up to 11,520 bus devices (15 x 12 x 64) can be controlled individually.

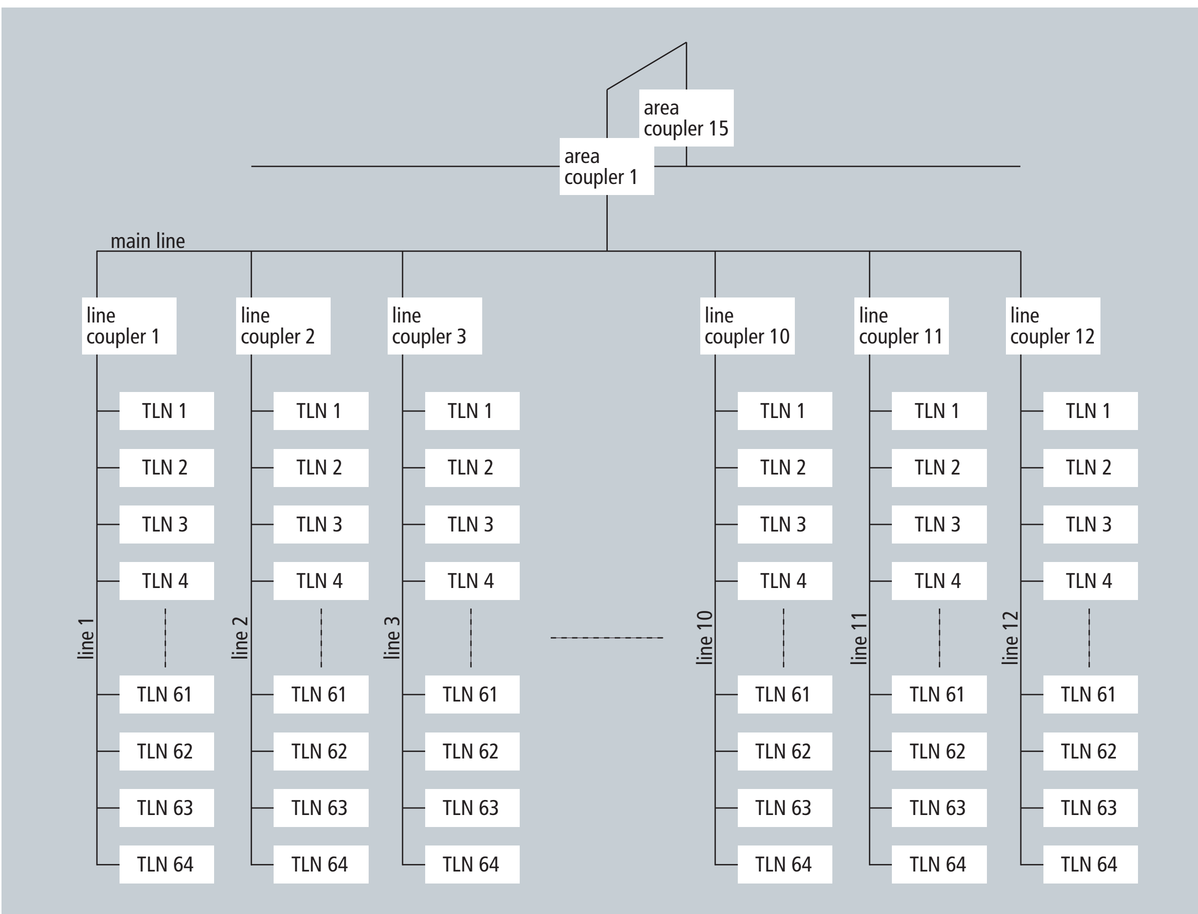

Fig. 1 Grouping of EIB devices in lines, main lines and area lines

A bus line can be subdivided into four segments, each with 64 devices (TN or TLN), but each line segment requires its own power supply. An EIB network with up to 45,900 TLNs can be created with such a structure.
In order to extend the structure of the lines, they are connected to the so-called main line by line couplers. The main line itself requires in turn at least one power supply and can interconnect a maximum of 12 lines. Main lines can be connected further via a so-called area line and thus extended. With this, 15 main lines can also be interconnected.

4.1 Cabling

Typical of EIB is the green EIB cable PYCYM 2 x 2 x 0.8 or the telephone cable J-Y (ST)Y 2 x 2 x 0.8, which is recommended for wiring. Terminal resistors (terminators) are not necessary.

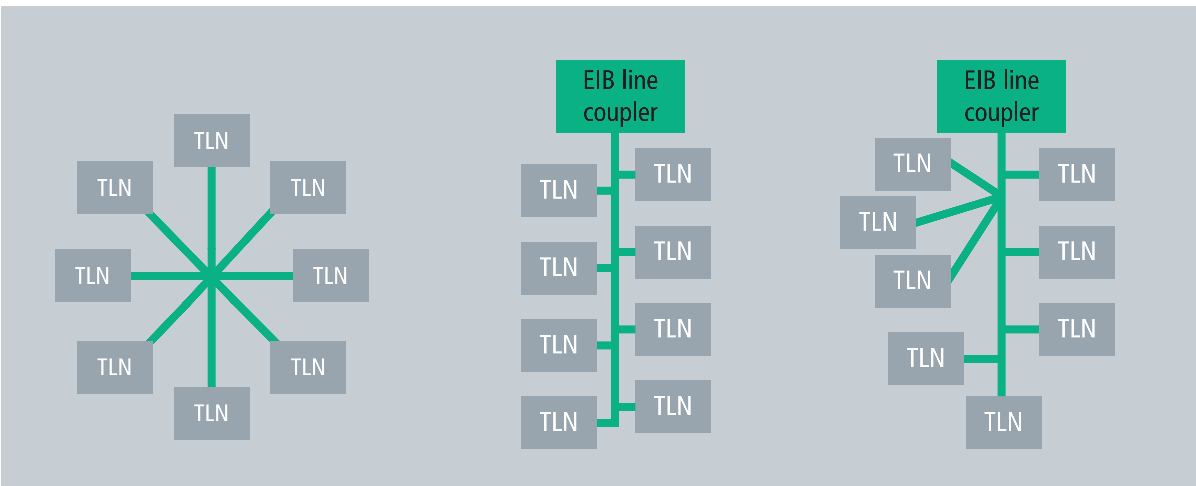

Fig. 2 Possible EIB topology

5. Communication

Different transmission speeds are possible, depending upon the transmission physics:

- Twisted pair 9,600 baud
- Powerline 1,200 to 2,400 baud
- Radio technology 19,200 baud

The Beckhoff KL6301 Bus Terminal for EIB integration supports twisted pair wiring with the following characteristics:

Characteristic of the EIB wiring (TP) when using the KL6301	
Max. length of the bus line without repeater	1,000 m
Max. distance between two devices	700 m
Max. distance between power supply and device	350 m
Min. distance between two power supplies	200 m
Number of devices per line	64
Number of power supplies per line	2
Max. number of devices in the EIB network	57,600
Termination resistor	not necessary
Bus access procedure	CSMA/CA

Tab. 2 Characteristic of the EIB wiring (TP) when using the KL6301

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5.1 Physical address/device address

The physical address identifies the individual bus devices and serves the purposes of programming, diagnostics and fault finding. The EIB address is uniquely assigned and retained; it indicates the area and the line in which the device is installed. The physical address is arranged according to area, line and device and is formally separated by dots. The number sequence 2.4.7 thus has the following meaning: in the 2nd area of the 4th line, device number 7. The physical address is assigned using the ETS during project engineering.

5.2 Group address

The group address or logical address specifies which sensor controls which actuator. The line in which the devices are located is thereby irrelevant. Each group address can be assigned to a device and can also be changed again as required. Unlike the physical address (2.4.7), group addresses are separated by forward slashes (1/4/18). Actuators can be assigned to several group addresses, but sensors can only transmit to one group address.
The group addresses are implemented in a two-level or a three-level structure. This gives rise to the possibility to divide the functions into main and sub-groups or into main-, mid- and sub-groups. A total of 16 main groups are available, each with 2,048 sub-groups (two levels) or 16 main-, 16 mid- and 256 sub-groups (three levels). The choice between two or three levels can be made in the ETS. The group addresses can be arranged according to different criteria. The Beckhoff KL6301 Bus Terminal for the integration of EIB lines supports the three-level structure.

5.3 Configuration of the devices

The programming of the devices and the assignment of the group addresses take place with a special, but likewise standardized software, the Engineering Tool Software (ETS), see section **8. Software**.

6. Power supply

Typical of EIB is the separation of the supply voltage (usually 230 V AC) and the control voltage (typically 30 V DC). Each EIB line needs a separate power supply unit in order to power the individual devices. Using the powerline variant, the devices can also be powered via the mains electricity supply. Wireless transmission is also possible. The Beckhoff Bus Terminal for EIB communication supports only the variants with separate voltages. The KL6301 EIB Bus Terminal has no integrated power supply.

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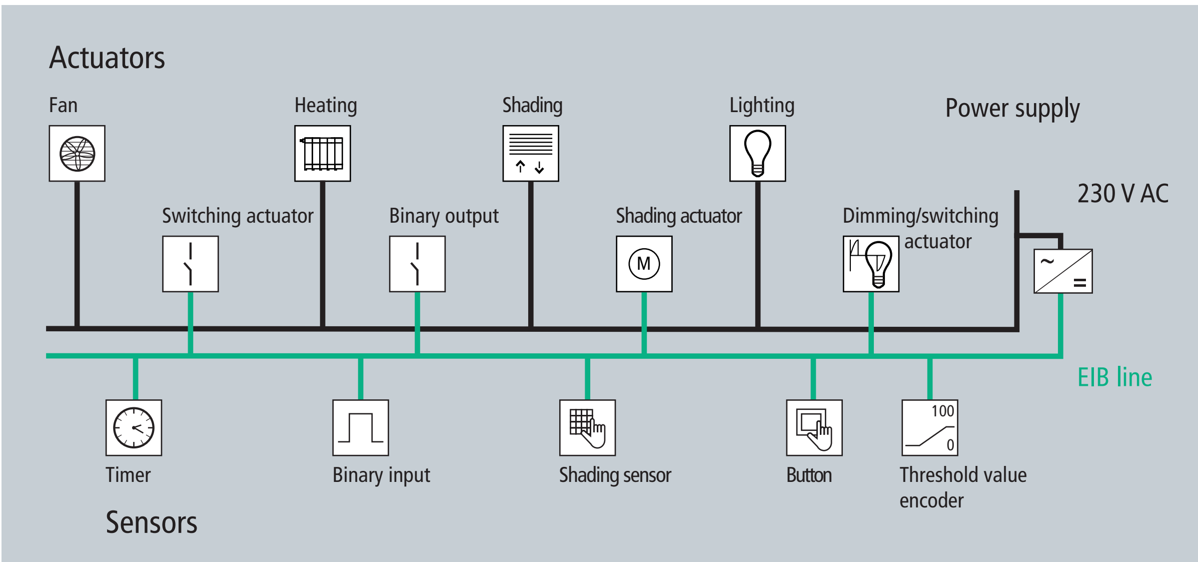

Fig.3 Separation of supply voltage and control voltage

7. KL6301 EIB Bus Terminal from Beckhoff

The KL6301 EIB Bus Terminal is integrated into EIB networks and can receive/transmit data from/to other EIB devices. Due to the KL6301 terminal's integration in the Bus Terminal system, EIB components can also be integrated in higher-level bus systems such as Ethernet. The commissioning and configuration of the KL6301 EIB terminal takes place exclusively via TwinCAT function blocks from the TwinCAT PLC library TcKL6301.lib, which has been specially developed for the EIB terminal. Status LEDs directly indicate the bus status. The EIB terminal operates independent of the bus system used. Several KL6301 terminals can be used with a single Bus Coupler or a Bus Terminal Controller. A maximum of 256 group addresses can be received; transmission is limited only by the application.

8. Software

Special programming software, 'Engineering Tool Software' (ETS), for example 'ETS®3', is necessary for the project engineering, commissioning and diagnosis of EIB systems. Irrespective of that, however, the programming and configuration of the EIB terminal takes place via the TwinCAT library TcKL6301.lib.

8.1 ETS – Engineering Tool-Software

The physical addresses of the devices and the logical linking of the devices with one another are specified by the ETS via group addressing. In detail, it is defined how the devices (actuators and sensors) interact. The ETS is also used for the administration of the EIB devices, including which EIB devices are installed in the building, where they are located inside the building and how they are configured in detail. All information and software characteristics concerned with the programming of an EIB product are located in a product database, which must be procured from the manufacturer. After downloading the product database

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(usually as a .vd2 or .vd3 file), all configuration options are available in the ETS. In the case of more complex devices, such as room control units, the detailed information and configuration settings are available as a plug-in.

The following illustration shows a screenshot of the current* version of ETS, ETS®3 (*the original, German language version of this document was released in July 2010).
Visible in the picture are the aforementioned three areas into which the user interface is divided.
In the upper third of fig. 4, the so-called **group address window**, the entire system is displayed from the point of view of the functions existing in it. It is easy to see here which devices in the building interact with one another and how.
A further important view is the **topology window**: It shows the topology of the bus system (middle third of fig. 4). The left half of the window shows an overview in the form of a tree structure; individual parts of the tree structure on the left are shown in the right half-window as details in the form of a list. The **main work window** (lower third of fig. 4) shows the system from the point of view of the building by showing the buildings with the rooms and distributors that they contain. The devices can be assigned to the rooms and distributors that contain them, so that it is easy to find the devices in software via their place of installation in the building.

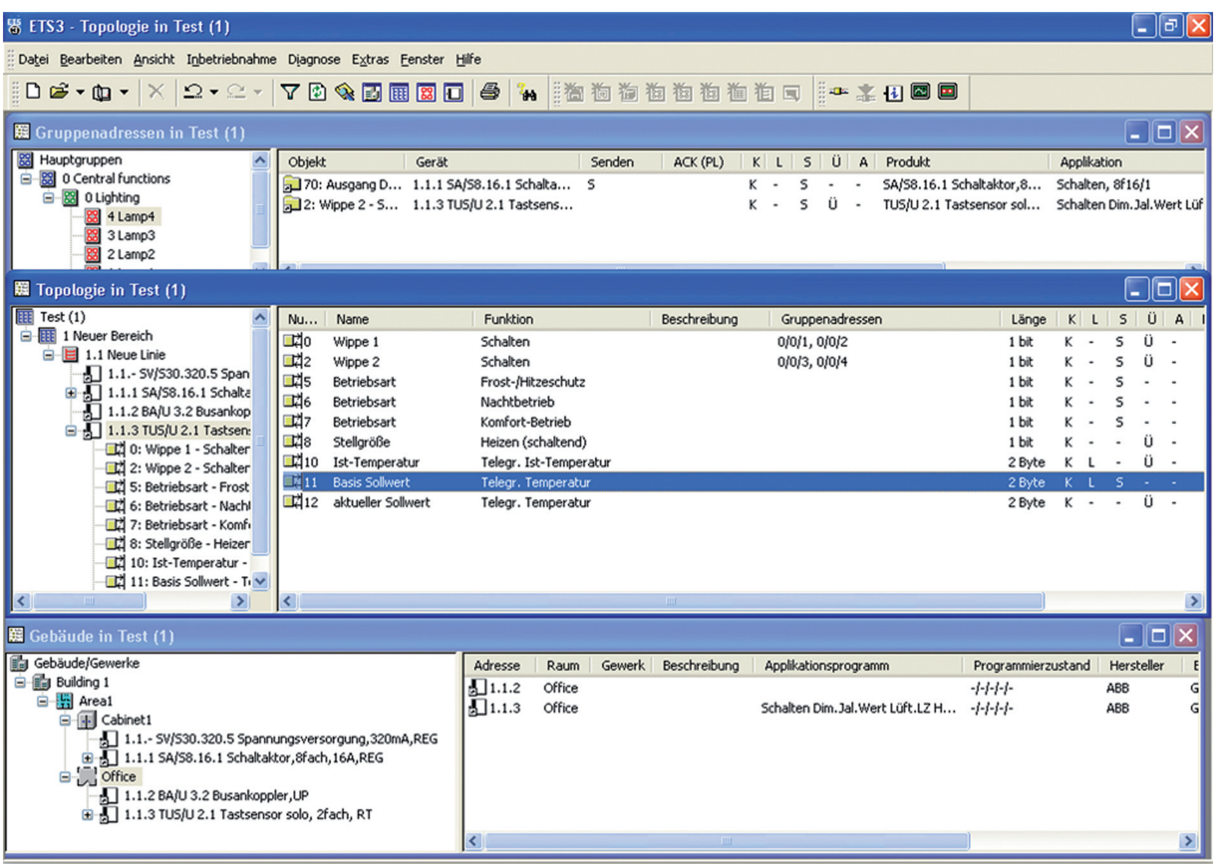

Fig.4 Screenshot of ETS®3

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First of all, the manufacturer's product data have to be loaded into the ETS database. After importing these data into the ETS database, the actual project engineering can begin. After the creation of the most important project data, the structure of the building is virtually simulated together with the corresponding EIB devices and the physical addresses are assigned. The characteristics of the EIB devices can be selected according to their intended function by means of imported product data. In the case of a button, for example, one can select whether this is to be used as a dimmer button, a switch or a start/stop button (for blinds). In the case of actuators, their behavior can be specified by time functions, for example. In the next step, the functions are specified within the plant and the group addresses are assigned. After that, the sensors and actuators are connected in order to assign inputs and outputs to the defined functions according to the IPO principle (input-processing-output). In addition, group addresses can optionally be assigned to the individual trades.

8.2 Integration in TwinCAT

The TwinCAT PLC library for the KL6301 provides the function blocks required for data exchange between the application program running on the PLC and the EIB devices connected to the KL6301. For communication, the function block FB_KL6301 of the basic interface is called, via which the configuration of the KL6301 is also carried out at the same time.

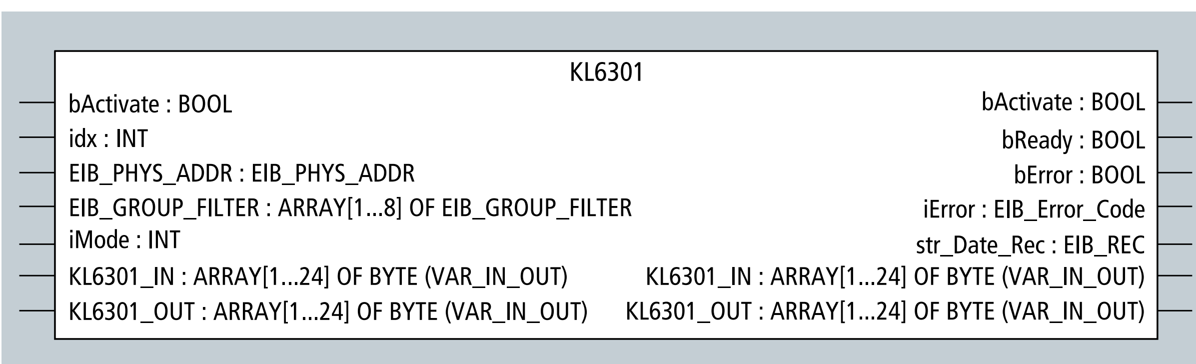

Fig 5 FB_KL6301 for communication of the EIB terminal with the devices

The EIB group filters have to be parameterized before the KL6301 can enter data exchange mode. Filters are necessary for all group-addressed data that are sent to the KL6301, since each group telegram contained in the filters replies with an ACK and is registered in the process data. Only then is the telegram visible in the function blocks! The KL6301 discards EIB telegrams with group addresses that are not included in the filter. Therefore, the EIB network must be coordinated with the filters of the KL6301: Either four group filters, each with 64 group addresses, or eight group filters, each with 32 group addresses, can be set on the receiving side of the KL6301. The main- and mid-groups within the filter are fixed, therefore only the sub-groups can be freely selected. Transmission is possible to all EIB devices in the network. The communication block can only be called once per PLC cycle and only once per terminal. If the group filters are not sufficient, it may be necessary to use additional KL6301 devices.

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The basic version of the interface additionally contains a collection of simple function blocks that reduce the programming effort and the value conversions. A transmit block and a receive block are available for each popular data value; transmission blocks transmit the data only in the event of changes.

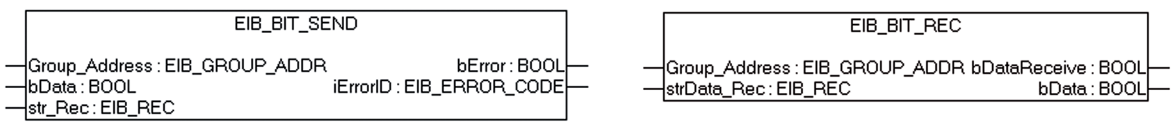

Fig. 6 Simple function blocks for transmission and reception; in this example: bit transmission/reception

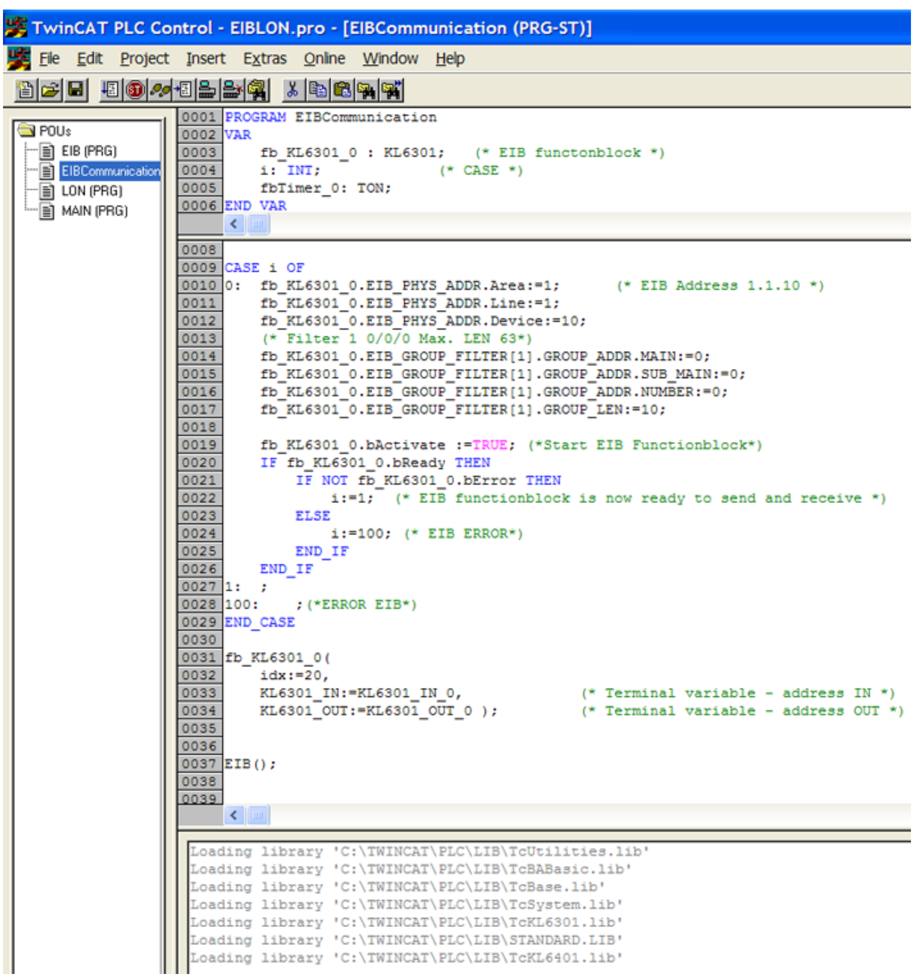

Fig. 7 View of the FB_KL6301 in ST

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9. Practical example

When automating a functional building, the office represents the smallest unit. An EIB-based room control unit, to which the corresponding units are connected, acts as a central control unit for the comfort-oriented room functions (temperature, ventilation, shading and lighting). All other components are connected via local input and output modules as Beckhoff Bus Terminals in order to reduce the use of materials for the cost-intensive EIB wiring.

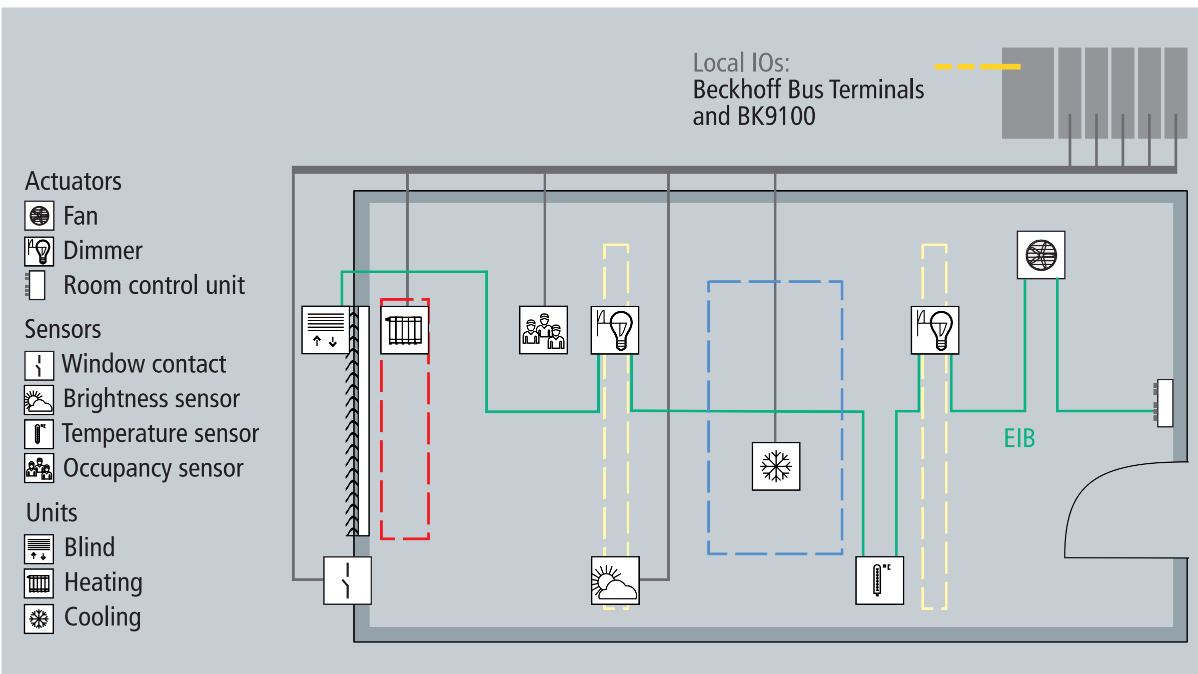

Fig. 8 **Each office represents a unit, which can be controlled separately via an EIB room control unit.**

The floors of the building are segmented in order to simplify maintenance and commissioning, i.e. several offices (four in this case) form a unit in which the programming routines and cable runs can be used. In this example, each segment is equipped with a BK9100 Ethernet TCP/IP Bus Coupler in order to pass the local I/Os through to the building management system (BMS). The example's room control units are integrated floor-by-floor via a KL6301 EIB Bus Terminal, which is connected to a CX8000 Embedded PC with other I/Os for the control of the floor.

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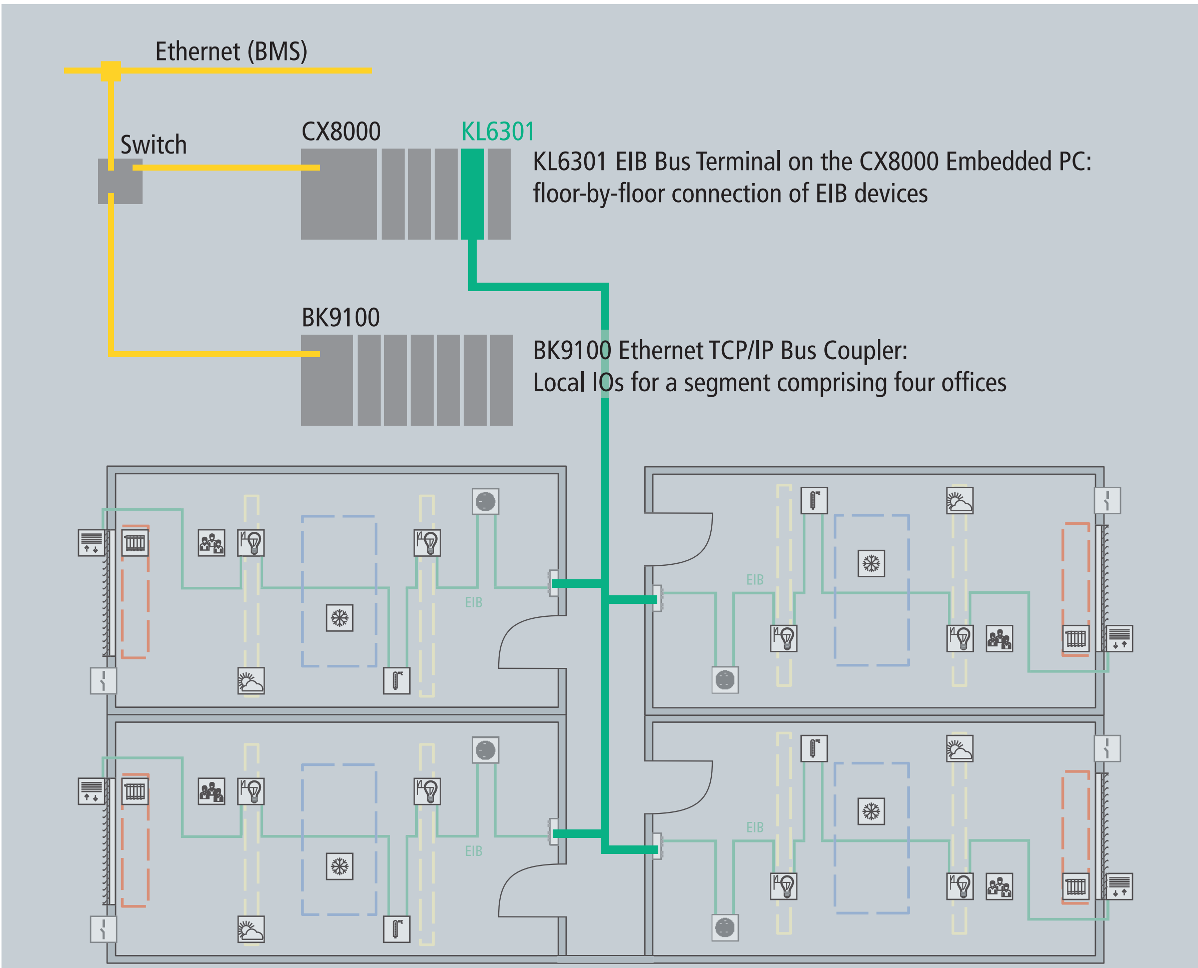

Fig. 9 Bundling of the offices on a floor via EIB and grouping of the devices within the controller according to trades

The use of Ethernet as the area line transmission medium increases the data throughput between the individual areas and additionally enables conversion to the less expensive Ethernet cable. Larger distances between the main lines can be bridged by using Ethernet and the commissioning procedure for the EIB network is simplified, since only the sub-segments need to be considered during commissioning.

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– EIB Bus Terminal **www.beckhoff.com/KL6301**

– Beckhoff Building Automation **www.beckhoff.com/building**

– Web page of KNX **www.knx.org**