Adaptive lighting system

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Abstract. The main requirement for lighting is energy efficiency, which can be achieved by using modern lamps and adapting lighting to natural light conditions and working conditions. Currently, light sources and controls are considered as a single device. There are a lot of ways to control lighting – LCN, ZigBee, KNX, DALI and others, the analysis of their characteristics leads to the choice of the DALI protocol, because it is compatible with third-party products, and this ensures the inclusion of additional devices and sensors in the system. Many existing systems take into account universal lighting standards, but not specific requirements for workplaces, for example, at the computer workstation. Working with the monitor requires the creation of certain hygienic conditions, in order to provide the minimum fatigue of the visual system. The aim of the research is to create a lighting control system based on the DALI protocol, which, unlike the existing ones, will rely on the testimony of two sensors, not one, and adapt to the conditions of natural light.

1. Introduction
The success of LED technology is steadily developing. Even if the lighting system is simple, but equipped with LEDs, it already saves resources and money, but only the dynamic adaptation of light to the relevant needs ensures maximum savings. Effective LED technology is truly effective with the use of appropriate control system, this concerns the lighting of streets, squares and public buildings [1–3]. The advantages are unlimited dimming, quick response to power-up commands, low power consumption and unlimited switching operations. In addition, perfect lighting control ensures that people will feel comfortable.

LED technology is developing, so the variety of LEDs are competing with each other, for example, the OLED and LED. They have different designs and properties: the advantages of OLED are transparency and flexibility, but LEDs are more common and customary. But the main problem of OLED – insufficient time of continuous work, this is due to the fact that one of the colors, namely blue, functions less than others [4]. On the market, to date, there are less OLEDs than LEDs, this is because traditional LEDs are much cheaper and more suitable for lighting [5].

An additional way to increase the efficiency of a sophisticated lighting control system is the maximum use of natural light in the daytime, in combination with adaptation to changing working conditions and controlling lighting throughout an entire building.

2. Theoretical review and formulation of the problem
As is known, at present the market offers a variety of lighting control systems, and the first is the LCN bus. Simple planning, installation, parameter setting and control, a wide range of functions and
intelligent modules - all this applies to the LCN-based bus management system. Only one wire is required for communication. Each of the bus modules has its own "intellect" in the form of a complex microprocessor, which means that the control system is decentralized. Each module will be able to solve its task, even after a power failure these modules are ready for use. This control system is used mainly to create complex systems, so it can include more than 30,000 individual modules [6].

The second control system is based on the ZigBee radio control. Wireless networks ZigBee are based on the standard IEEE 802.15.4 [7]. In such a system, devices, switches, buttons and sensors of various manufacturers can be integrated. The system allows the radio connection of devices at distances of up to 100 m. Programming and parameterization are performed either using two buttons on the control module, or using the ZigBee software. Each module can be programmed for an individual and for a permanent task. Also, the modules are immediately ready for use after a power failure [8].

The third control system is based on the KNX management protocol. It works with the KNX gateway. This system can interact with the additional elements built into it. For example, motion sensors, lighting sensors, lighting fixtures and other devices. And most importantly, in the management system on KNX it is possible to embed modules of other standards, but using special converters [9].

The fourth control system is based on the DALI control protocol, according to the EN 62386 standard [10]. DALI was specifically designed to manage the automation of buildings. DALI systems can be easily integrated into the building management system.

In the DALI line, 64 addresses (devices) can be assigned. The line itself requires a power supply for the DALI bus. Each module can be programmed for an individual and for a permanent task. Also, the modules are immediately ready for use after a power failure. Particularly well, the DALI system can be implemented on LED lighting fixtures. The advantages are unlimited dimming, quick response to power-up commands, low power consumption and unlimited switching operations.

We have undertaken this project to create a system that is adaptive to daylight, therefore, after analyzing the different types of lighting control, it is obvious that for the solution of the problem it is better to use the DALI protocol, since daylight control will require additional components of third-party manufacturers [11-13].

3. Elements selection, practical results of the constructing

The basis for the control system will serve the DALI protocol, as the most suitable for the constructing of this system. The main feature of the created lighting system will be strict compliance with the requirements of normative documents [14-19] for lighting workstations with monitors and the ability to adapt to changing conditions of daylight.

The structure of the lighting control system created in accordance with [20] and includes the following blocks: a power supply unit (supply elements), a sensor unit (light sensors), a device unit (LED lamp and smart glass) and a control unit (control elements).

Based on this, the elements for the implementation of this lighting system were selected:

- ModBus DALI Gateway GW2 (RAINBOW) - used to convert control protocols, namely from RS-485 protocol to DALI.
- OVEN PLC150-220.U-M - used for lighting control, namely the elements of the developed system.
- Lighting fixture: Varton A070 - used to control artificial lighting. LED light is more suitable than an OLED lamp, since it is much cheaper and its usable life is much longer.
- Smart Film: PDLC SmartFilm - used to control natural light. The choice fell on it, because smart glass is much more expensive than this film.
- Light sensor: visible light sensors LP02 built-in cable with analog output (4-20mA) in a flat housing D30x6mm (House-Sensor project) - used to remove the illumination readings, according to which it will be determined whether lighting adjustment is required.
• Power supply: DR-75-24 (Mean Well) - used to convert 230 V to 24 V, since some devices in the system require 24 V power.
• Circuit-breaker: automatic circuit breaker 16A With BA47-29 4.5kA (MVA20-2-016-C) (IEK) - it is used for safety purposes.
• Bus power supply: DALI PS - used to power the DALI bus to which controlled devices will be connected.

According to the selected elements, a general electrical diagram was developed (Figure 1).

![Electrical Diagram](image)

**Figure 1. Electrical diagram.**

Elements on the diagram are denoted as follows: QF1 - circuit breaker; 3G1 - power supply 24V; 3G2 - DALI bus power supply; BP1 and BP2 - light sensors; HL1 - LED lighting fixture; SS1 - smart glass; PLC - PLC150-220; U - ModBus DALI gateway.

These elements selection allows the creation of an adaptive lighting control system, which differs from the existing minimum cost with maximum energy efficiency; it scales easily depending on the number of work places; uses daylight maximally; ensures strict compliance with the standards for workplaces with displays.

4. Conclusion
For maximum energy efficiency it is necessary to use dynamic adaptation of lighting to working conditions. Lighting can be controlled by a variety of ways that have their advantages and disadvantages, but we chose DALI based control, because this method was developed specifically for lighting control and helps avoid a lot of compatibility problems with components.

After analyzing the elements on the market, an adaptive lighting control system was constructed. The operation of the system is represented by a general electrical diagram. Features of the created
system is adaptation to the excess daylight and exact maintenance of the normative values of illumination for workplaces with displays due to the use of two sensors, instead of one, as in many other systems.

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Acknowledgments
The work was supported by Act 211 Government of the Russian Federation, contract no.02.A03.21.0011.