

DESIGN OF INTELLIGENT LIGHTING SYSTEMS BASED ON IOT AND THEIR ENERGY EFFICIENCY

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This article presents four main methods of controlling lighting systems: automatic, IoT and remote, graphic, and artificial intelligence-based control. These methods are analyzed, and the most efficient one «automatic control» has been selected. In this method, efficiency in the lighting system is achieved by regulating heat through a special controller.

Keywords: Automatic control, lighting system, IoT, controller, temperature sensor, artificial intelligence, remote control.

ПРОЕКТИРОВАНИЕ ИНТЕЛЛЕКТУАЛЬНЫХ СИСТЕМ ОСВЕЩЕНИЯ НА ОСНОВЕ ИНТЕРНЕТА ВЕЩЕЙ (ИОТ) И ИХ ЭНЕРГОЭФФЕКТИВНОСТЬ

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В данной статье представлены четыре основных метода управления системами освещения: автоматическое, IoT и дистанционное, графическое, а также управление на основе искусственного интеллекта. Эти методы проанализированы, и наиболее эффективным выбран автоматический метод управления. В этом методе эффективность системы освещения достигается за счёт регулирования тепла с помощью специального контроллера.

Ключевые слова: автоматическое управление, система освещения, IoT, контроллер, датчик температуры, искусственный интеллект, дистанционное управление.

Nowadays, the demand for energy is increasing significantly. The main reason for this is the growing number of electricity consumers. In the world, lighting accounts for about 15–20 % of total electricity consumption. From this, the issue of saving electricity arises, which is very important for both people and industrial enterprises. In this regard, digitalization plays a very important role.

Because by digitalizing a system, that is, using the Internet of Things, it is possible to achieve significant efficiency not only in the energy sector but also in other systems. Implementing digitalization in lighting systems can reduce energy consumption by 10–35 %.

In the energy sector, there are four methods of improving the efficiency of lighting systems in a digitalized form. Table 1 below presents several approaches that contribute to efficiency. These include automatic control of the lighting system, remote control, graphic-based control, and the use of artificial intelligence to select the optimal operating mode. Among these methods, the most effective ones are automatic control of the lighting system and heat management, as well as selecting the optimal mode by analyzing user conditions. The other methods presented in the table can also be very useful depending on the circumstances. For example, the remote control system of lighting is considered quite convenient for certain users, and although its efficiency percentage is relatively low, it is still one of the most optimal methods for them. The method with the lowest efficiency percentage is graphic-based control, in which efficiency is achieved by switching the lighting system on and off at fixed times. For instance, in some industrial enterprises, turning lighting devices on and off according to a strict schedule leads to achieving efficiency Remote control, that is, real-time control, as we can see, accounts for 15–25 %. This method allows the use of lighting devices only when needed. The use of artificial intelligence in lighting systems also provides sufficient efficiency. One of the functions of this method is to normalize the room’s lighting based on the amount of external light [1; 2].

Table 1

Methods of achieving efficiency through a digitalized lighting system

Methods	Implementation	Efficiency
Automatic control	Controlling light and heat	20–40 %
IoT and Remote control	Using lighting devices when needed	15–25 %
Graphic-based control	Operating the lighting system at specific times	10–20 %
AI-based optimization	Selecting the optimal mode based on conditions	25–35 %

However, one of the most optimal methods among those mentioned above is automatic thermal and light control. In Table 2 below, the regulation of lighting systems through thermal management is presented. There are four types of thermal management systems: passive, active, electronic, and combined methods. By using these methods, it is possible to achieve efficiency of up to 40–92 % in lighting systems [3].

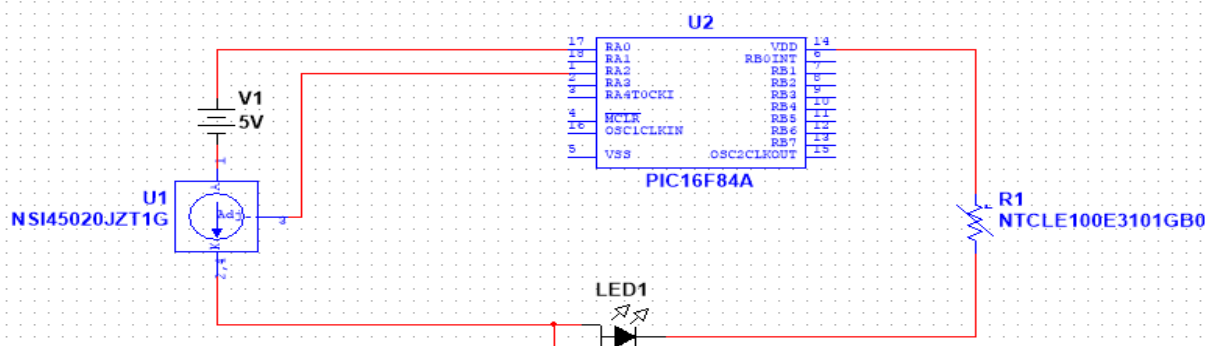
We implement the following method to ensure the lighting system through automatic thermal control. Figure below shows the schematic diagram of controlling the lighting system through thermal management, which consists of a DC power supply, an LED driver, an LED lamp, a temperature sensor, and a controller [4].

Table 2

Types of thermal management systems

Type	Advantages	Disadvantages	Method	Applica-tion Area	Efficiency
Passive	No energy consumption, simple, reliable	Requires large size, insufficient for high power	Heat sink (aluminum, copper)	Small projectors, LED lamps	60–75 %
	Cheap, convenient	Poor air circulation	Natural convection	Open-type lamps	40–55 %
	Improves thermal conductivity	Loses quality over time	Thermal paste	LED modules, chips	70–85 %

Type	Advantages	Disadvantages	Method	Applica-tion Area	Efficiency
Active	Fast heat dissipation	Additional energy consumption, noise	Fan	High-power luminaires, LED projectors	75–90 %
	High accuracy in temperature control	Expensive	Peltier module (TEC)	Optical devices	50–70 %
	Excellent efficiency	Expensive and complex	Liquid cooling	Speciali-zed high-power LED systems	85–95 %
Combi-ned	High efficiency	Requires complex additional maintenance	Fan + Heat sink	Industrial lamps, stadium projectors	80–92 %
Elect-ronic	Protection from overheating, real-time monitoring	Requires additional electronics	Sensor-based control	Smart LED lamps	75–85 %
	Increases efficiency	Complex control algorithm	Voltage regulation	LED systems	80–90 %
	Longer lifespan	Reduced luminous flux	Automatic current limiting	Energy-efficient LED systems	65–80 %



Schematic diagram of achieving efficiency in the lighting system through thermal management

After converting the incoming 220V AC voltage from the grid to 5V, the lighting device is supplied with a power source. Once the lighting system is powered, it is connected to the lighting device through the LED driver. At this stage, the LED driver is linked to the controller. The controller, in turn, is directly connected to the temperature sensor. In this process, the controller helps maintain the normal temperature of the lighting device.

Based on the information provided above, it can be concluded that the issue of saving electrical energy is highly important today. Since the electricity consumption of lighting systems has great significance on a global scale, energy-saving and efficiency-enhancing methods in this field are considered crucial. The method of controlling lighting systems through thermal management is also regarded as one of the important scientific approaches.

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