AUTONOMOUS LIGHT-EMITTING-DIODE (LED) LOW VOLTAGE SYSTEMS OF LIGHTING INTEGRATED INTO "SMART HOME"

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Abstract - This paper considers the low-voltage system of lighting power supply with the possibility of integration with alternative energy sources without additional devices, such as voltage converters and generators, etc. using LEDs.

1 INTRODUCTION

At the moment most countries use lighting systems with high-voltage power supply - 220, 110 volts. At the same time, development of new technologies in the field of alternative energy and production of highly-efficient reliable LED crystals with increased capacity gives the possibility of changing the old approach of organizing the lighting of the building.

The basic, crucially new feature is the coincidence of LED elements power supply of lightning and alternative sources of electric energy (solar panels) - 24 volts, which allows developing new architecture of lighting systems with the possibility of autonomous operation. In this article we suggest the solution that will help to put into practice lighting systems of higher energy-efficiency and make the Republic of Kazakhstan a patent owner of new generation lighting systems. The system change of power supply will significantly reduce the energy consumption through the use of LED lighting units.

In Kazakhstan, production and sale of 100W and above electric incandescent lamps are under a ban introduced from the 1st of July, 2012; 75W and above - from the 1st of January, 2013 and 25W light bulbs are recycled from the 1st of January 2014. The forecast of McKinzey consulting company - in 2015 LEDs will replace the traditional incandescent and luminescent lamps, occupying 50% of the market in money terms and in 2020 - 90% of the market in money terms and 75-80% in real terms.

Low-voltage power supply systems are mainly used for lighting and illumination of mirrors, bookshelves, portraits, photographs, as well as for landscape lighting, buildings and gardens. The proposed low-voltage power supply of 24 volts allows switching to LED lighting with the integration of renewable energy renewable energy sources (RES) [1-6].

The use of low-voltage power supplies is first of all due to the high reliability of performance that can significantly increase the life of the energy supply devices. Also the use of low-voltage power supply system increases electrical safety and fire safety of premises.

2 MAIN PART OF THE RESEARCH

Replacement of traditional sources to alternative involves the creation of high-quality reliable power supply of LEDs allowing considerably reduce the pulsation of light and improve the efficient use of electric energy [1-6].

Solar panels are widespread among the renewable energy sources. Various devices, allowing converting solar radiation into heat and electrical energy, are the object of study of helioenergetics. Production of photovoltaic cells and solar collectors is growing rapidly in many different directions. Solar panels can be various sizes: from built into calculators to occupying the roof of vehicles and buildings.

The use of solar panels is under the control of specialized controllers allow to solve problems of autonomous lightning of both internal and external objects [4]. Examples of such objects include: remote building (hunting shelters, yurts, camp sites, mobile trailers, drilling rigs); hard to reach areas (highlands); areas that require illumination at night (streets, parks, yards, gardens); recharging the batteries of household appliances (mobile phones, laptops, portable TVs). Examples of organizing the autonomous operation mode of internal and external lighting are shown in Figure 1, 2 and 3.

Figure 1 shows the general scheme of using solar panels in the lighting system. The generated electricity is supplied by solar panel into the converter, where its voltage increases from 24 volts to 220 volts. After the converter, the generated electricity is used for lighting and household needs.

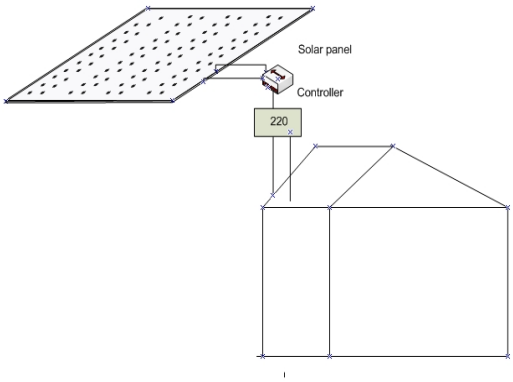


Figure 1. The scheme of using solar panels in the lighting system

Figure 2 shows the appearance of a yurt with autonomous lighting, a vertical stripe on the yurt is a solar panel.

Figure 2: Organization of the autonomous operation mode of the internal lightning of the yurt

To ensure the stable operation of the autonomous system of lighting one of the key elements is the controller [7-8], operating the current of the batteries charging and providing the necessary voltage to the system load. Visually, the controller with the control system (Figure 3) and a spotlight on LED elements (Figure 4), illuminating the yurt, are shown in Figures 3 and 4.

Figure 3. Controller with operating system

Used in our scheme controller automatically switches the voltage level from 12V to 24V and vice versa when different types of solar cells are used [4]. Also it automatically changes the voltage when you change storage batteries types to recharge them and to provide the required load voltage.

The following figure 4 shows the spotlight with LED elements that illuminate the yurt.

Figure 4. LED spotlights connected to low-voltage power supply system

Let's consider the controller with operating system in more detail scheme shown in Figure 5.

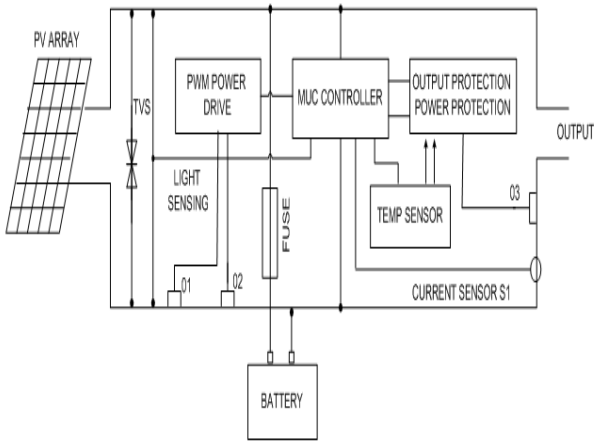


Figure 5. Structural scheme of the controller used

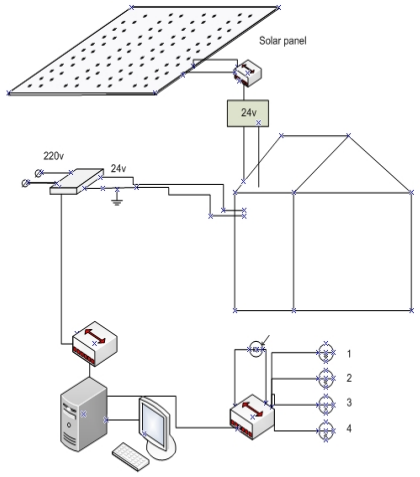
PV voltage of a solar panel is input to the controller having a diode decoupling (Figure 5). Then positive voltage is supplied through the system aligned in accordance with the level of battery charging current charging. This possibility is realized by controlling transistors Q1, Q2 by changing current of the base-collector (PWM Power Drive) controlled by built-in microprocessor (MUC Controller). Depending on the charge level of the storage battery and the voltage level, supplied from the solar cell, control voltage (current) is carried out using the transistor Q3 for an output load connected to the controller.

In general, implementing the control of the battery charging and output voltage level, a smooth functioning of the devices connected to this controller is provided. The control of connected devices operation is provided by the sensor S1 operation and digital indication, derived on the front panel of the controller.

Replacement of traditional sources to alternative involves the creation of high-quality reliable power supply of LEDs allowing considerably reduce the pulsation of light and improve the efficient use of electric energy.

Target-oriented approach for the solution of this issue will show the principle advantages in efficiency and safety of low-voltage lighting systems based on LED lighting units, and also will provide an opportunity to test and implement efficiency comparison.

The scheme of using low-voltage lighting without energy converter is shown in Figure 6.



1 - Movement-detecting sensor, 2 - Luminance sensor, 3 - Time sensor, 4 - Presence sensor

Figure 6. Scheme of using solar panels in the low-voltage lighting system

As shown in Figure 6, the generated electric power with a voltage of 24 volts is supplied into the lighting system from the solar cell. The voltage of generated electric power of the solar panel is identical to the voltage of LED lamps [8-9].

Thus, autonomous LED low-voltage lightning system integrated into "smart home" use:

1 low-voltage lightning system

2 light-emitting-diode (LED)

3 $U_{LED}=U_{sol.\ p.}$

Using low-voltage lighting has the following advantages:

1. using alternative energy sources in the lightning system
2. energy saving up to 70% in the lighting system industrial and administrative buildings
3. operating life of the lightning system increases in 10–50 times
4. depreciation expenses decrease in 50-100 times (due to high reliability and operating time of LEDs, solar cells and developed power supply source)
5. safe operation of the system is ensured by switching on the operating voltage of in the 24 volts lighting network.

Implementation of the system of intelligent building with low-voltage lighting can significantly improve the efficiency, liquidity, prestige, comfort and functionality of the "Smart home", due to:

– reducing operating costs on the object maintenance;
– reducing the risk of fire;
– increasing the comfort of being in the room and simplicity of equipment operation ("simple, like a switch");
– scalability of the system;
– unified principle of all electrical equipment control;

– modern design, high quality, reliability of equipment.

Structural construction of low-voltage lighting electrical systems

The area of lighting systems application is very diverse. For simplicity, we have to consider the construction of lighting systems in separate rooms with windows [3], providing a pre-determined level of illumination from 6 a.m. to 10 p.m. The daily cycle of the room illumination shown in Figure 7 corresponds to natural light. According to the schedule there is no need for artificial lighting from 9 a.m. to 5 p.m. Moreover, there is an excess of natural light, which must be eliminated by limiting the access of natural light into the room. From 6 a.m. to 9 a.m. and from 5p.m. to 10p.m. there is not enough natural light and it is necessary to switch on the lights.

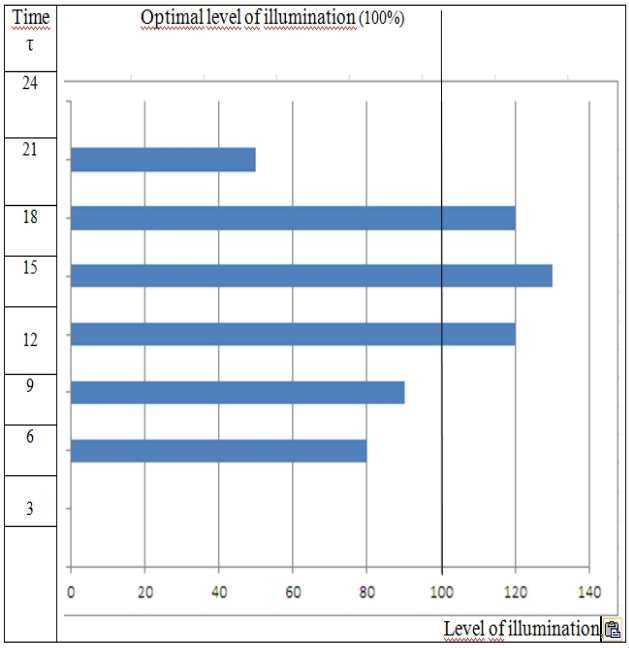
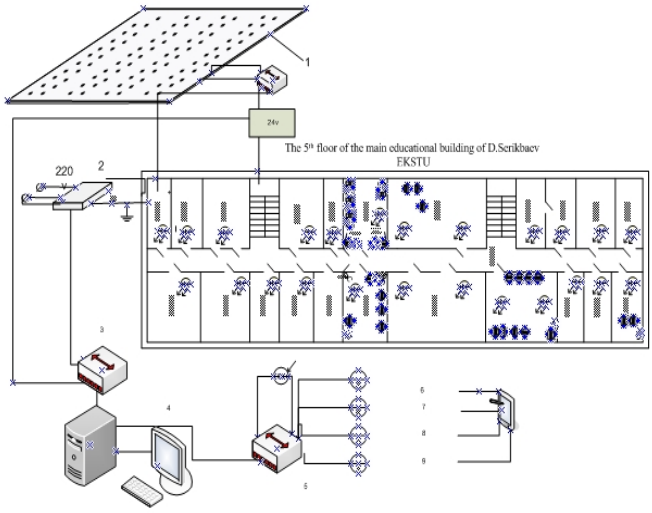


Figure 7. Daily cycle of the room illumination

In this regard there is a potential possibility of energy saving, if to switch on the lighting not to full capacity, but just enough to fill the shortage of natural light. Sure Figure 6 does not show changeless day cycle that is subjected to calendar and the weather changes.

Thus, the scheme of lighting system with distributed mains-operated automatic lighting [3] is shown in Figure 8. The figure shows the real low-voltage lighting system implemented in the educational building of D.Serikbaev EKSTU. This figure shows the 5th floor with LED control system of lights. The lighting system is based on smart actuators (actuator), operating control final control devices, and smart sensors (sensor). The word "smart" emphasizes the fact that the composition of each device has an artificial intelligence - the microcontroller. Sensors and actuators are powered from a common electrical network and may exchange messages through a local area network based on the data line in accordance with a certain standard protocol. This data line may be implemented as a twisted pair of conductors, a virtual channel with frequency control directly in a power network or a radio channel. Besides saving of non-ferrous metals, such system has two additional very important advantages. The first is to realize the connection of additional devices and, therefore, the expansion of functions.



1 - Solar panel, 2 - LED driver, 3 - Controller, 4 - Lightning server, 5 - Adapting module , 6 - Movement-detecting sensor,
7 - Luminance sensor, 8 - Time sensor, 9 - Presence sensor

Figure 8. Scheme of the lighting system with distributed mains-operated automatic lighting

For example the presence sensor can be connected if there are people in the room on and it will switch off the lights if there are completely no people in the room. It is easy to suppose that due to this additional function, one can get a significant energy saving, especially in the auxiliary buildings: warehouses, corridors, closets, elevators, etc. The second advantage is the possibility of a hierarchical network construction, which interconnects local area networks of separate premises into the floor lighting system, and the control system of the floors - into the building operation system, etc., access to such a hierarchical network of computers connected to the Internet, allows remote control of the system from anywhere in the world.

The result of putting into operation the lighting system with solar cells will reduce electricity consumption by 8 times compared to luminescent.

Using a distributed mains-operated system allows to integrate lighting control system into an intelligent control system of the "smart home" [3, 11-12]. This will save electrical energy into 5-7 times.

It is not difficult to see that for realization of all these functions it is enough to add into the system a specific set of intelligent sensors and actuators shown in Table 1.

Table 1

Sensors and actuators of the "Smart home" system

Function	Sensors	Actuators
Lights control	Lighting Presence of people Real time	Lights control Blinds control
Air conditioning	Air temperature Air humidity Meteorological parameters	Heating control Air conditioners control Ventilation system control
Protection from unauthorized entry	Alarm sensors Surveillance video-cameras Personal identification sensors	Audio equipment control Locking system control Alarm control Connection with repair services
Technical systems security control	Electricity supply sensors Flood sensors Gas leakage sensors	Emergency switching control Connection with repair services
Remote control	Remote control sensors (infrared, radio, etc.)	Information displays control

Thus, it is very promising to build a control system of electric lighting on the principle of distributed network operation. For this purpose, it is necessary to develop a range of industry-standards of interfaces and protocols for the construction of low voltage lighting.

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