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DEVELOPMENT OF TEST SITE ON THE BASIS OF LED LAMPS FOR DEBUGGING SOFTWARE OF WIRELESS NETWORK FOR PROCESSES AUTOMATION MODULES

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ABSTRACT

The test site is designed for testing and debugging the software of the wireless network for processes automation (WNPA) modules; debugging and setting the function of local and remote control of objects using WNPA modules; debugging and setting the self-diagnostics function of WNPA modules and their communication channels; debugging WNPA module configuration function.The WNPA module is designed for use in embedded applications that require low data transfer rates and low power consumption. The goal is to create an inexpensive, self-organizing network with a mesh topology designed for a wide range of tasks. The network can be used in industrial control, built-in sensors, medical data collection, warning of intrusion or smoke, building and home automation, etc.

Keywords: test site, software debugging, lamp, parameter control, wireless data transmission, wireless module, debugging, monitoring, wireless network.

1. INTRODUCTION

To ensure maximum comfort, the lighting system should provide the best color climate, which is the feature of the spectral composition of lighting. In order to optimize the lighting parameters, the influence of the color temperature of LED lamps on the efficiency and emotional state of a person was studied.

The scientific search by domestic and foreign researchers [1-3, 7] evidences a noticeable influence of the color temperature level of flux of light sources on human circadian rhythms - cyclic fluctuations in intensity of various biological processes associated with the change of day and night. It is generally accepted that "warm" colors help relax and prepare for sleep. A "neutral" (about 4,000 K) color temperature is recommended for work, and more "cold" tones provoke higher mental activity [2, 4]. These well-known postulates are based mainly on the results of scientific achievements of the last century, when the object of scientific research on lighting equipment was incandescent lamps and gas-discharge light sources.

Most publications in journals on lighting are devoted to LED lamps, which are becoming increasingly popular due to the rapid development of this industry. They are considered to be a solution of some economic and technical problems under the conditions of the global crisis, in particular, those related to the need to provide comfortable working and living conditions. The spectral composition of LED lighting is very different from that of incandescent lamps and gas-discharge light sources. The processes of human visual perception are so complex that it would be wrong to assign to any light source the properties inherent in others. Thus, there is a need to develop and apply various methods to control both the intensity and the spectral composition of lamp emission.

The development of wireless communication modules is of considerable interest for the control of lighting systems. The main feature of WNPA modules is that at low power consumption they support not only simple network topologies, but also self-organizing and self-healing mesh topology with relaying and message routing [1]. In addition, there is a choice of the routing algorithm, depending on application requirements and network status, applications standardization mechanism – applications profiles, standard cluster library, endpoints, bindings, flexible security mechanism, ensuring easy deploying, maintenance and upgrading.

The main areas of application of WNPA modules are wireless sensor networks, house automation (Smart Home and Intellectual Building), medical equipment, industrial monitoring and control systems (in our case – lamps), as well as consumer electronics and PC peripherals. The WNPA module specification is oriented to applications that require guaranteed secured data transmission at relatively low speeds and the long-term operation of network devices [2] from autonomous power supplies.

2. METHOD OF SYSTEM OPERATION CONTROL

The test site consists of control system, lamps (luminaires), WNPA modules. Each luminaire must be equipped with a power supply with control, connected to the WNPA module, and is the final device of the test site. A classroom is allocated at the university as the test site. Luminaires and control system are installed in the classroom. Part of the luminaires are placed in adjacent corridors for greater naturalness of testing.

The control system of the test site is a PC with WNPA module via USB. On the PC, softwareis installed to debug and set WNPA modules (Figure-1).

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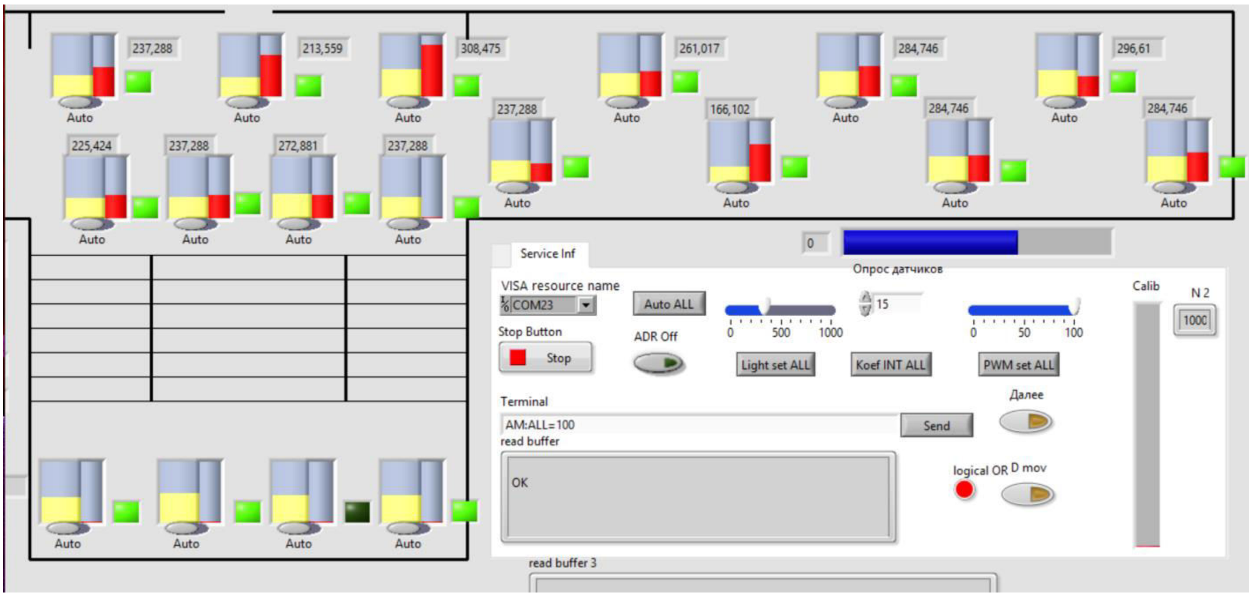

Figure-1. The front panel of the software for tuning, debugging WNPA modules.

Luminaires are an object of control using the integrated WNPA module. At the moment, several options for integration are considered: the WNPA module with Bluetooth, Wi-Fi, Ethernet or IrDA. On the luminaires, the processes of gathering information on the control object, monitoring / controlling its operation, self-organization of the WNPA modules into the network, stability of the network, monitoring of energy consumption, etc. are being debugged. We use luminaires, since our partners are manufacturers of lighting products.

The test site consists of a PC, specialized software, luminaires with WNPA modules and a brightness adjustment driver, which are connected via a wireless network [3]. A PC with special software installed serves as a source of the control signal. The system has the most extensive capabilities of all embedded systems, it allows:

- applying any color-dynamic effects for both the group consisting of identical LED luminaires, and the group of luminaires of different models;
- creating, saving and editing lighting scenarios and lighting of any duration, comprising any number of effects;
- adjusting the brightness and saturation of light;
- monitoring the level of current consumption;
- viewing the created scenario of lighting in the university in real time;
- adding new devices to the network. It is only reflected on software (for example, it will be possible to collect water-meters data or control the door opening in the classroom);
- automatically turning on/off the lighting by the fact of the presence/absence of people in the room. The time intervals of the light-off timer's delay from motion sensors and light sensors can be set by the user during operation;
- controlling emergencies: accidents, fire, unauthorized access to protected premises.

In addition, to expand the ability to monitor and control the whole system by lighting in the university [4], one can connect the PC to the Internet, which will enable to easily get information on the work and condition of the luminaires in the classroom via a mobile phone.

Figure-2 shows an example of the test site's operation.

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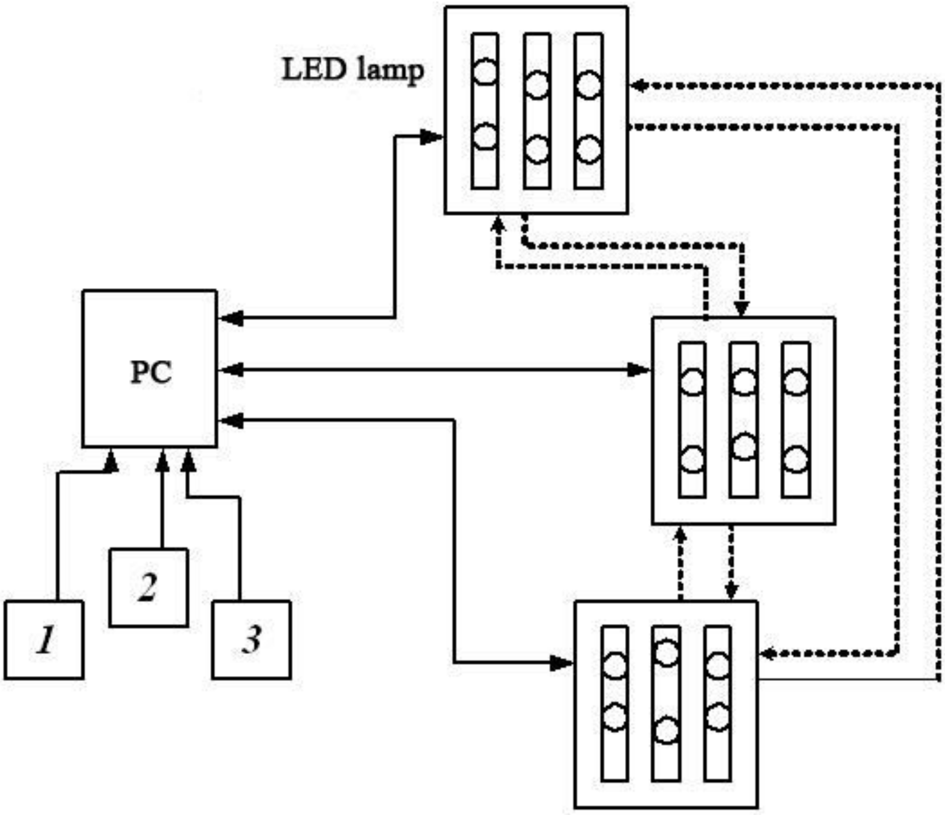

Figure-2. Scheme of operation of the test site:
1, 2, 3 - parameters (presence of people, illumination in the room, etc.); PC - personal computer; ▪▪▪▪▪▪▪▪▪▪ - wireless communication lines

The development of the system included the following main stages:

a) Elaboration of technical requirements for the test site. At this stage, technical requirements are developed, a patent information search is conducted, a feasibility study is prepared for the development, with the rationalization of the need, the planned cost of the product and the economic parameters of the introduction (economic effect).

b) Development of design and technical documentation. At this stage, an information report is being written, a draft of technical specifications is being developed.

c) Making of experimental samples of WNPA modules. At this stage, materials and components are purchased, a necessary set of WNPA modules is manufactured, tests are conducted, the experimental sample is finalized and design documentation is updated based on test results; engineering conditions and operational documentation are developed.

d) Creation of the test site in the university.

e) Software testing of experimental samples of WNPA models. At this stage, test program and methodology are developed, operational and acceptance tests are done with subsequent installation and adjustment.

The experimental batch of LED luminaires is located in Building D on the second floor (Figure-3).

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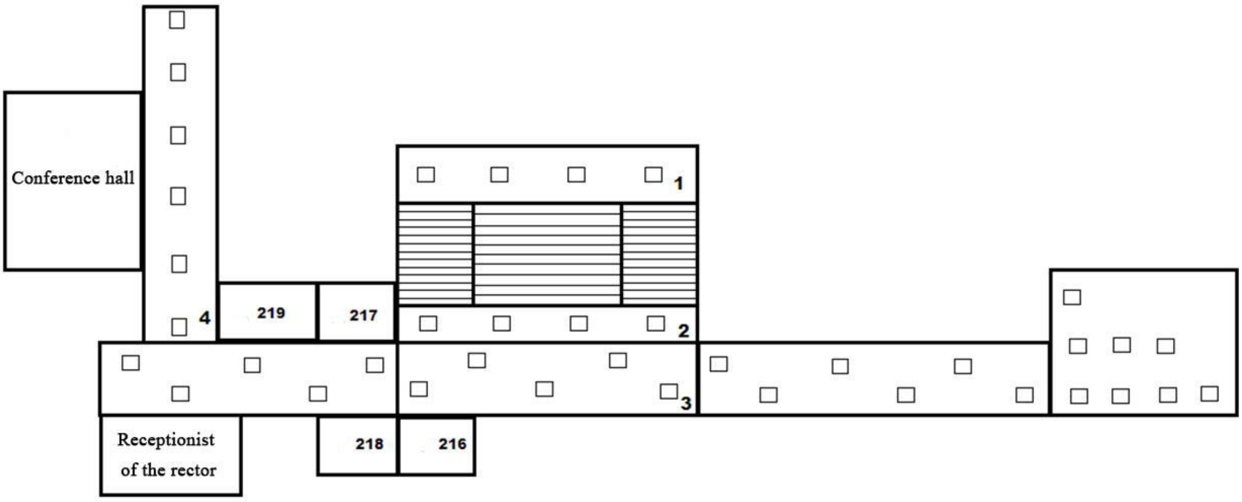

Figure-3. Scheme of the second floor of Building D: 1- the first group, 2 - the second group, 3 -the third group, 4 - the fourth group of luminaires

The first group (Figure 3) of the luminaires located along window openings will automatically respond to the level of illumination and simulate a light day, namely: turn on at full power in the dark, while in cloudy weather and in the daytime adjust the brightness in accordance with the norms on illumination.

The second group of luminaires is intended for illumination of the stairs platform and by the functional purpose is close to the first group. However, this area receives significantly less daylight. The control system will reduce the cost on electricity by automatically adjusting the level of illumination and thus the intensity of the emission from the luminaires.

The third group of luminaires located in the lobby of the second floor should not also have a full power load, since part of the daylight penetrates into this area. Automatic dimming by means of the built-in control system will allow regulating in a timely manner the intensity of luminous flux from the luminaires.

The fourth group of luminaires is located in the corridor on the second floor near Conference Hall. The length of the corridor and uneven distribution of windows create a sharp drop in illumination. Unlike the previous zones, this area is less crowded, and accordingly, does not require maintaining a high level of illumination. The control algorithm of this group of luminaires will take into account all these nuances. Our system will allow leveling the illumination, and automatically reducing, in the absence of people in the corridor, the luminous flux to the level of standby lighting.

All groups of luminaires will automatically respond to the presence of a person, turning on/off if necessary. Regulation of illumination of each luminaire separately will allow providing considerable saving of power consumption. With the help of a single control center for monitoring, it is possible to monitor the status of a single luminaire or the entire system as a whole which will allow monitoring and automatically controlling the state of the system in real time.

The basic modes of operation of the test site are shown in Table-1.

Table-1. Operating modes of the lighting system.

No.	Lighting modes	Functions	Features
1	Primary lighting	1) providing visibility, 2) control of illumination, 3) presence control	1) smooth regulation of intensity of the light flux 2) switching on/off and changing the brightness of luminaires
2	Standby lighting	1) lighting for duty staff 2) selective switch on of individual luminaires 3) presence control	1) low level of illumination 2) work at a given time interval (at night)
3	Emergency lighting	1) stable maintenance of the level of illumination required in emergencies	1) impossibility of independent (command-free) transition to other modes

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3. RESULTS OF RESEARCH

The test site is used not only for debugging the software of WNPA modules, but also for studying the influence of different color temperature on the psychoemotional state of a person.

According to the generally accepted doctrine, ensuring high reliability of test results involves the use of at least two representative samples. One of them is called the "experimental" group, and the other is called the "control" group. Therefore, testing was conducted in two classrooms with different types of lighting. The curricula of the university's department provide for various types of classes using a variety of assessment tools in oral and written forms with an obligatory interactive component. This gave ample opportunities for planning and doing innovative research, being of tremendous importance for the development of national economic sectors, and enabling to obtain new scientific and technical results.

The experiment consisted of two cycles and took three months. In the studies, male and female students aged 20-22 were involved as test persons. The sample size was limited to the number of students in the group. Three types of test tasks were used; assessment of attention, performance, fatigue was carried out with the help of correction tasks and tapping-test, while assessment of the emotional state - using a WAM (wellbeing, activity, mood) questionnaire. Testing was carried out twice a day under different lighting conditions: lamps with fluorescent lamps (FL) with a color temperature Tc = 4,000 K and LED lighting (Tc = 2,800, 4,000, 5, 800 K).

Analysis of the test results showed that in more than half of the respondents, when illuminated by LED lamps with a color temperature Tc = 5,800K ("cold light"), activity increased. The assumption that visual performance should correlate with the four studied illumination modes was confirmed. When testing students in a room with LED lighting and a color temperature (Tc) equal to 5,800 K compared to fluorescent lighting, the rate of doing test tasks and productivity increased by up to 15-20% ($p \leq 0.05$). The influence of various lighting modes on the psychophysiological background was revealed, in particular, the tendency to relax with "warm" LED lighting (Tc = 2,800K).

4. DISCUSSIONS OF RESULTS

Practical application of lighting systems capable of changing the intensity and spectrum of emission from luminaires, if necessary, imitating a light day, will help maintain a favorable light microclimate in premises and improve the psychophysical state of people.

This development is also directed to the solution of problems of energy and resource saving and is not limited only to replacing some luminaires with more economizing light sources. Further development of the topic involves the use of solar modules or other alternative sources of electrical power, which will significantly reduce the costs on electricity. The innovative lighting system (Figure-4) will be able to receive electrical power from a standard power supply network, solar panels being located outside Building D, and wind generators being located on the roof of one of the academic buildings of Kazan State Power Engineering University.

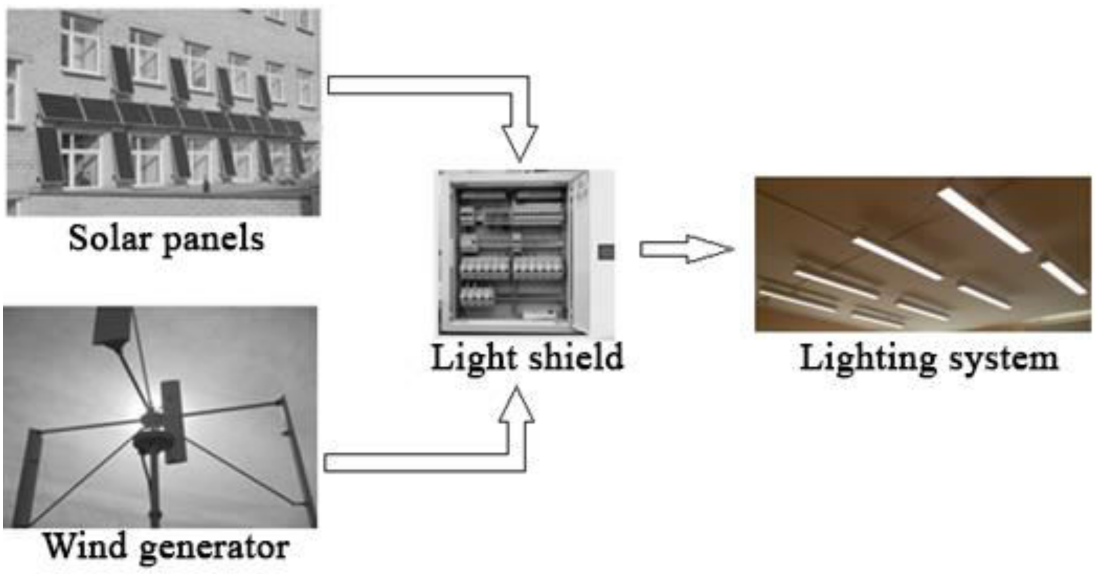

Figure-4. Structural diagram of an innovative lighting system with alternative energy sources.

The traditional power network in this case will be an additional measure designed to ensure the continuity of electrical power supply of the lighting system.

The opportunities of practical application of the results of our research in the economy [5-11] include promoting fundamentally new products as a catalyst for the growth of relevant sectors of the economy. In addition, widespread use of analogues of the described innovative lighting system and alternative energy devices - solar batteries and wind generators - as sources of electrical power will cause a significant reduction in the costs on electricity.

CONCLUSIONS

Thus, a testing ground has been established for debugging the software of BSAP modules, consisting of control system, luminaires, WNPA modules. Each luminaire is equipped with a power supply with control, being connected to the WNPA module, and is the final device of the test site. All final devices of the test site for debugging the software of the WNPA modules meet the following requirements: they operate in industrial and public buildings networks under standard radiophone conditions at relative humidity not more than 80%; provide current consumption for the WNPA modules in receiving mode not more than 200 mA, in transmission mode not more than 300 mA, in sleep mode not more than 10 mA. The control system for the testing ground for debugging the WNPA modules software is a hardware and software complex that provides receiving and processing of serial data packages of experimental WNPA modules compatible with the hardware protocol of the universal asynchronous transfer protocol.

Experimental samples of the WNPA module compliant with Bluetooth, Wi-Fi, PLC, Ethernet, USB, RS-485, IrDA communication protocols will be designed to monitor the status of objects, the automation of corporate and public buildings via collection and transmission of information from external sensors, automatic relaying of transmission data, creating continuous information coverage of large area with a broadcast access to all nodes on the network [5-7].

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