ABSTRACT
dissertations for the degree «Doctor of Philosophy» (PhD) in specialty 6D070200 – «Automation and control»
ALIMKHANOVA ASLIMA ZHENISKYZY

AMBIENT ASSISTED LIVING AUTOMATED CONTROL SYSTEM BY USING VLC

The relevance of the work. The leading countries of the world have adopted and are implementing national programs for the digitalization of the economy. This trend is associated with the digital revolution taking place in all sectors of the economy and spheres of people's lives. Each country identifies priorities for digital development, focusing on its needs. In Kazakhstan, in 2017, the government approved the state program "Digital Kazakhstan", which is aimed at improving the quality of life of Kazakhstanis through the widespread introduction of digital technologies into their life. The objectives of the program cover a wide range and their solutions should become the basis in the future for the transition of the republic to the digital economy. One of the priorities is the task associated with the expansion of the coverage of communication networks and the availability of information and communication technologies. The implementation of the digital economy is impossible without the development of information and communication infrastructure and the introduction of new innovative approaches in this industry.

Modern trends in the field of information and communication technologies consist in providing the possibility of introducing the concept of a computing and communication network of physical objects equipped with embedded systems for interaction with each other and with the external environment in automated control systems, and in particular in life support parameter control systems.

The home automation system is becoming more and more popular. People want to live in intelligent "smart" living spaces equipped with home automation systems. Such systems not only provide them with convenience, comfort, safety, but also reduce their daily expenses due to energy-saving solutions. Traditional control systems use solutions for wired connection of devices. However, the introduction of such systems requires laying cables and it is most rational to do this simultaneously with the construction of a house. Currently, in home automation, wireless technologies Wi-Fi, Bluetooth, Zigbee., which use the radio frequency spectrum, are mainly used for receiving and transmitting data.

For the process of data exchange and the operation of applications of "smart" systems, it is necessary to form a special environment that will provide high data transfer rates, low signal latency, and maintain a high density of subscriber devices. Wireless technologies operating in the radio frequency range are overloaded and cannot fully meet the requirements of modern life.

The home automation system requires low cost, low power consumption and does not require high data transfer rates. In our work, we propose to use the optical wireless communication technology Visible Light Communication. VLC is

a new wireless communication technology based on data transmission through LED lighting systems. LED is currently replacing universal incandescent and fluorescent lamps from our lives. The advantages of LED lighting devices are long service life, low energy consumption and high light output, reliability, environmental friendliness. In addition, the LED has a high response sensitivity with the ability to support high-speed communication. In VLC, the LED performs the functions of both communication and lighting, that is, with dual functionality.

This technology allows you to reduce electricity consumption, since lighting devices will be used as an information transmission channel. VLC technology increases the security of information transmission without loss. Along with these characteristics, the technology provides license-free operation, since the systems operate in an unregulated spectrum. Therefore, we suggest additionally using Wi-Fi data transmission technology over a visible network.

VLC is an advanced optical wireless communication technology that can simultaneously provide lighting and wireless data transmission. This system has a number of advantages: high transmission speed, secure transmission of information, dual functionality, absence of interference from electromagnetic waves.

The relevance of the topic of the dissertation work is due to the need to meet the needs of a rapidly growing number of subscribers with wireless traffic supporting the quality of the required services. The research is aimed at developing applications using VLC technology for indoor communication, where it complements Wi-Fi and cellular wireless communication.

The purpose of the work. To develop an automated control system for life support parameters with the organization of data transmission through LED lighting systems.

The main idea of the work is to use the existing infrastructure of the LED lighting system to introduce wireless communication technology for short-range applications. The motivation for the use of LED lights is the use of "green" technology for wireless communication, as opposed to radio frequency.

Research objectives:

1) To analyze optical wireless technologies and the possibility of organizing data transmission using Visible Light Communication technology.

2) Selection of the modulation method for data transmission via LEDs based on the analysis of the proposed modulation methods in the optical wireless communication system.

3) Develop a receiving and transmitting device using LED lighting for data transmission in wireless control systems.

4) Conduct experimental studies of an automated life support parameter management system with data transmission using Visible Light Communication technology.

The object of research is automated life support parameter management systems. The subject of the study is data transmission via wireless optical technology via visible light in control systems.

Main research methods: general scientific theoretical and experimental methods, such as analysis, simulation modeling, experiment, were used in the performance of the dissertation work. Methods of modulation in a wireless optical network, methods of the theory of automatic control were used as special ones. During the computer simulation, the Simulink program of the MATLAB package was used, calculations were carried out in the Microsoft Excel program. The development of the circuit design of the experimental device was carried out in the Splan 7.0 program, and the software using the visual programming environment FLProg.

Scientific provisions submitted for protection:

1) A model of the receiving-transmitting path system using OOK-NRZ modulation that allows data to be transmitted over a wireless optical channel.

2) A receiving and transmitting device with a light stream data transmission channel using powerful white LEDs using Visible Light Communication technology.

3) LED lighting system with the function of transmitting data via an optical channel in an automated control system for life support parameters.

Scientific novelty:

- a receiving and transmitting device using Visible Light Communication technology has been developed for an automated control system with the function of implementing control actions;

- a new approach to the organization of data transmission in an automated system for controlling life support parameters via a wireless optical channel by means of an LED lighting system is proposed.

Validity and reliability. The results of theoretical calculations, computer modeling and experimental studies show high comparability, which indicates the reliability and validity of the results of the dissertation work.

Scientific and practical significance of the work

The findings of the study can be used to solve problems related to electromagnetic interference, to increase the bandwidth of communication channels, as well as to develop hybrid data transmission architectures for wireless systems in automation.

The obtained scientific and practical results of the dissertation work were adopted for the implementation of BFGROUP LLP, ISTOCKCHEMI LLP, as well as in the educational process of D.Serikbayev EKTU. The implementation acts are given in Appendix A.

Approbation of the work. The results of the work were reported and discussed at international conferences in Hungary, Russia and Kazakhstan, namely: the 14th International Symposium on Applied Informatics and Related Fields (Szekesfehervar, Hungary, 2019); the International Scientific and Technical Conference of Students, Undergraduates and Young Scientists "Creativity of young innovative Development and Kazakhstan" (Ust-Kamenogorsk, Kazakhstan, 2019,2020); the 21st International Conference on Micro/Nanotechnology and Electronic Devices (Erlagol, Russia, 2020); International Scientific and Practical Conference “FarEastCon"/Far Eastern Federal University (Vladivostok, Russia,

2020); Ural Symposium on Biomedical Engineering, Radio Electronics and Information Technologies (Yekaterinburg, Russia, 2021); International Siberian Conference on Management and Communications (Kazan, Russia, 2021).

Publications. The author has published 16 publications on the topic of the dissertation, including 1 article in a journal indexed in the database indexed in Web of Science, having an Impact Factor for 2020 equal to 1,806 and a quartile for engineering and interdisciplinary works Q3; 5 works in publications recommended by the Committee for Control in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan and 6 publications in collections of international conferences indexed in the Scopus database.

The structure and scope of the dissertation. The dissertation work consists of an introduction, 4 sections, a conclusion, a list of used sources from 106 titles. The work is presented on 92 pages of computer text, includes 57 figures, 3 tables and 1 appendix.

The first part of the paper presents an analysis of the technology of data transmission based on visible light. Optical wireless data transmission technologies are analyzed. The organization of data transmission using Visible Light Communication technology is considered. Based on the analysis of scientific research on the subject of the work, the purpose and objectives of the dissertation were formulated. The relevance of the development of an automated life support management system using data transmission technology through visible light is substantiated.

In the second part of the work, modulation methods in a wireless optical communication network are considered. The modulation characteristics that are important for improving the performance of the new system are studied. For pulse modulation types, the spectral power density is calculated and investigated to obtain time waveforms with a given signal-to-noise ratio. A model of an ideal reception-transmission system for OOC-NRZ in the presence of additive white Gaussian noise is constructed, which is suitable for indoor VLC systems. Signal forms and the influence of instrumental and external noises are investigated. Calculated values of the probability of bit error according to experimental data are given.

The third section presents circuit solutions for transmitting and receiving modules based on ATmega microcontrollers, where light was used as a communication line. Software has been developed in the FLProg programming environment for microcontrollers. On the basis of the developed schemes, an experimental receiving and transmitting device was assembled and an experiment was conducted. Stable data transmission using a powerful white LED and physical coding of the light signal using UART technology is demonstrated.

In the fourth section, an approach to the organization of an automated control system for life support parameters based on the principle of data transmission over the visible spectrum in one direction is proposed. Control contours, direct and indirect indicators of each contour are highlighted. The implementation is demonstrated by the example of the organization of an automated temperature control system in a room. Experimental data are presented.

In conclusion, the main conclusions are formulated based on the results of the presented results of the dissertation work.

The appendix contains the acts of implementation of the obtained practical and scientific results.