

ANNOTATION
dissertations for the degree «Doctor of Philosophy» (PhD) in
specialty 6D070200 – «Automation and control»
Alibekkyzy Karlygash

**DEVELOPMENT OF LED LIGHTING SYSTEM WITH DATA
TRANSMISSION FUNCTION BASED ON VLC TECHNOLOGY**

General characteristics of the work: the dissertation work is devoted to the development of methods for ensuring the information security of critical objects that are resistant to intra-system interference and external intentional electromagnetic influences, it becomes extremely necessary. Such stability acquires an integrated assessment - robustness. The problem of electromagnetic security is solved by VLC (Visible Light Communication) technology, which refers to wireless communication using the visible range of optical radiation (from 380 nm to 780 nm). Light-emitting diodes (LED) are used as a data transmission source. Due to the fact that LED lighting is widely used in modern cars, the problem of introducing VLC technologies for these purposes is greatly simplified. One of the main advantages of this technology is its speed, which provides operation in the nanosecond time range, which makes it possible to use VLC technology for data transmission, both in analog and digital modes.

Keywords: system, LED, photodiode, robustness, VLC technologies, reliability, errors, metrology, software, simulation models.

The relevance of research. In the digitalization program of many states, one of the key areas is robotization, and in particular, the widespread introduction of unmanned vehicles in freight and passenger transportation. The development of unmanned vehicles was divided into three main areas: consumer, industrial and military. One of the goals in the implementation of this scientific and practical problem is the exclusion of the human factor, which will increase the safety of traffic and technical and economic efficiency. Many of the technical challenges that arise in this project are greatly simplified in the mass production of electric vehicles. At the same time, the requirements for the security system in the motor transport logistics system are increasing. There was a need to create an external control of the positioning of a motor transport vehicle along the entire programmable trajectory of movement and external diagnostics of the technical condition of unmanned vehicles (UAVs). For the purposes of local control, stationary points are created along the route of the UAV. Traditionally, communication with the rolling stock on the route of movement is carried out via a radio channel, which at present facilitates the task of external uncontrolled dangerous interference in the UAV control process. Under these conditions, the concept of "susceptibility to interference" appeared, which determines the ability of a technical tool that processes information, when exposed to electromagnetic interference, to distort the content or permanently lose information, stop or disrupt the control process,

change the composition and sequence of functions, and also physically destroy microelements.

The main idea of this study is to further develop the theory of information security management and improve the metrological reliability of control and decision-making processes at the stages of the life cycle of optoelectronic VLC systems.

As the analysis of literary sources has shown, the tasks of designing VLC systems should be classified as weakly formalized, since the design is carried out under conditions of statistical uncertainty of design agents, and the system can be operated in an environment of unauthorized external electromagnetic interference. The key integrated indicator of the quality of a multiparametric optoelectronic object is robustness, which is interpreted as the functional and operational reliability of the system. These characteristics should include the noise immunity and stability of the VLC system under the conditions of external anthropogenic, natural-climatic and active intentional electromagnetic interference.

In management, both at the system-wide level, and in particular design, production, technological and operational tasks of the life cycle of an object, the most important function is control. The quality of control is a multifactorial function that determines the level of errors and risks at the decision-making stage. It was found that the statistical reliability of the results of instrumental control in the design and operation of VLC systems is a composition of the laws of distribution of controlled parameters, the law of distribution of the measurement error and the law of distribution of standard values, where the “uncertainty” of type “A” in these system agents becomes decisive

The object of research is the process of data transmission quality control in VLC systems.

The subject of research is an automated system for secure data transmission based on VLC communications.

Purpose of the study. The purpose of the study is to ensure the electromagnetic security of communication channels based on VLC technologies.

Research objectives. In accordance with the goal, the following research tasks are set and solved:

- development of a structurally functional model of an automated system for robust control of the VLC system;
- development of models of fuzzy and stochastically programmed quality management of system support for a robotic traffic flow based on VLC technologies;
- improving the technical support of the robotic traffic flow control system based on VLC technologies;
- computer experiment for assessing and predicting management risks in the VLC communications system.

Research methods. To solve the tasks set, the basic principles and methods of designing optoelectronic systems, mathematical modeling methods and the theory of experiment planning were used.

Scientific provisions and results submitted for defense:

1. Structural and functional model of automated control of LED lighting, which makes it possible to increase the efficiency of vehicle management in the urban traffic cycle through the integrated use of receiving and transmitting data in the optical range;

2. Quality control model of a robotic car flow based on VLC technology, based on the principles of fuzzy and stochastically programmed approaches.

3. Quality management model for control and measurement processes at the stages of the life cycle of VLC systems, including those including instrumental and algorithmic support.

4. Algorithm for simulation modeling of risks in the control system of technological parameters in conditions of non-deterministic standards.

5. Model of optimization of control processes in the system of production and operation of VLC systems for robotic cargo transportation.

Scientific novelty of the dissertation research:

1. Conceptual and methodological approach to the design of VLC systems with wireless data transmission channels.

2. Methods of robust design of automated VLC communications in the system for ensuring electromagnetic security of technical and socio-economic objects.

3. Fuzzy and stochastic model of automated quality control of robotic traffic flows based on VLC technology.

Scientific and practical significance of the work.

The results of the dissertation work are aimed at improving the efficiency of the system of information and technically secure communications in industrial and cultural facilities based on VLC technologies. The functionality of VLC channels is implemented by a multi-parameter composition: technical, mathematical, software and information support. Practical significance is confirmed by acts of implementation.

Statement of the problem, formulation of research tasks, development of software for the VLC system, software development, planning and implementation of experimental and computer experiments, development of recommendations for the implementation of research results obtained personally by the author of the dissertation.

The main provisions of the dissertation, its individual decisions and results were reported at the meetings of the School of Information Systems and Intelligent Systems of non-profit joint-stock company «D. Serikbayev East Kazakhstan technical university».

Approbation of work. The main provisions and results of the work were reported and approved at the following international and scientific conferences:

1) 12th International Symposium on Applied Informatics and Related Areas AIS 2017 (AIS-2017)". – Szekesfehervar. Hungary. 2017.;

2) Bulletin Almanach science association France-Kazakhstan, 2019/4.

3) International scientific and technical conference of students, undergraduates and young scientists "Creativity of young innovative development of Kazakhstan". Part IV, 2020.

4) International scientific and technical conference of students, undergraduates and young scientists "Creativity of young innovative development of Kazakhstan". Part IV, 2020C.

5) Materials of the International Scientific Conference "Priorities for the Development of Science and Education", Turkestan, November 15-16, 2021;

Publications. The results obtained in the dissertation were published in 12 papers, including 1 article in a journal peer-reviewed in the Scopus database (CiteScore percentile is 37%), 3 articles in publications recommended by the Committee for Control in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, 2 papers in scientific journals, 5 papers in collections of international conferences (1 of which is reviewed in the Scopus database). There are also 1 copyright certificate No. 17432 dated 05/12/2021, 1 monograph.

The structure and scope of the dissertation. The dissertation consists of an introduction, 4 chapters, a conclusion, a list of references from 109 titles presented on 98 pages of computer text, includes 62 figures, 4 tables and 3 appendices.

The introduction substantiates the relevance of the research topic, the purpose, object, subject, tasks and methods of research, scientific novelty, scientific provisions, practical value and implementation of the results of the work, provides information about publications and approbation of the work.

The first section provides an overview and analysis of existing approaches, methods and technical support for a data transmission system based on VLC technology. The features of the application of these methods are studied and described, on the basis of which conclusions are drawn on the first section.

The second section provides a theoretical study of the problem of robust quality control of VLC communications under the conditions of statistical uncertainty of system agents. Control uncertainty is represented by a composition: uncertainty of the regulatory framework of structural and technological processes, uncertainty of the operating modes of the VLC system, uncertainty of metrological support, uncertainty of the constructive component environment, uncertainty of the external working environment.

The third section presents a software product that implements the functions of processing expert assessments to determine the "weights" of individual indicators of each section, calculating the rating of an object, taking into account expert assessments. The expert information obtained in the future can be used in the quality management system.

The fourth section presents the collection of statistical data in the process of laboratory testing and operational research, the primary processing of experimental information. Based on the modeling materials of the second section and statistical data from laboratory and operational studies, as well as the software package of the third section, it was planned to carry out a computer experiment. The computer experiment technique pursued the goal of evaluating the adequacy of theoretical assumptions and simulation results to real operational data.

In conclusion, the results of the work done in the framework of the dissertation work are summed up.

The content of the dissertation ends with a list of references and applications.