REVIEW

by Eng. Dimitar Mihaylov Tokmakov, Ph.D

Professor at the ECIT department, Faculty of Physics and Technology,

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on the dissertation for the award of the educational and scientific degree "PhD"

by: field of higher education: *5 Technical sciences*

Professional field : *5.3. Communication and computer engineering*

Doctoral programme: "*Automation of areas of the intangible sphere (medicine, education, science, administration, etc.)"*

Author: *Snezha Ventzislavova Shotarova*

Topic:” INTERACTIVE LABORATORY FOR INFORMATION PROCESSING WITH REMOTE ACCESS”

Scientific supervisor:

Assoc. Prof. Silviya Stoyanova-Petrova , Ph.D - Paisii Hilendarski University of Plovdiv

1. General description of the presented materials

By order no. RD-22-430/23.02.2026 of the Rector of the University of Plovdiv "Paisii Hilendarski" (PU) I have been appointed as a member of the scientific jury for the defense of a dissertation work on Snezha Ventzislavova Shotarova on the topic:" Interactive laboratory for information processing with remote access ", presented for the acquisition of the educational and scientific degree "doctor" in the field of higher education 5. Technical sciences, professional field, 5.3. Communication and computer engineering, doctoral programme Automation of areas of the intangible sphere (medicine, education, science, administrative activity, etc.).

Mag. Eng. Snezha Ventsislavova Shotarova has been enrolled in full-time study at the Department of “Electronics, Communications and Information Technologies” (ECIT) at Paisii Hilendarski University of Plovdiv under the academic supervision of Assoc. Prof. Silvia Velkova Stoyanova–Petrova, PhD.

The submitted set of materials in hard copy by Mag. Eng. Snezha Ventsislavova Shotarova complies with Article 36 (1) of the Regulations for the Development of the Academic Staff of the University of Plovdiv and includes the following documents:

- an application addressed to the Rector of the University of Plovdiv for initiating the procedure for the defense of a doctoral dissertation;
- a Curriculum Vitae in European format;
- a statement from the supervisor regarding the initiation of the defense procedure;
- minutes from the Department Council meeting concerning the reporting of readiness to open the procedure and the preliminary discussion of the dissertation;
- the doctoral dissertation;
- an abstract of the dissertation;
- a list and copies of scientific publications related to the dissertation topic.

2. Brief biographical data for the doctoral student

I know the doctoral candidate personally, and I obtained the biographical information from the submitted curriculum vitae.

Mag. Eng. Snezha Ventsislavova Shotarova graduated in Hardware and Software Systems from the Faculty of Physics and Technology at the University of Plovdiv "Paisii Hilendarski," obtaining a Bachelor's degree in 2019. In 2020, she completed the same specialization at the same faculty and university, obtaining a Master's degree.

Her professional career began at SD "Zhanesi", continued at Arexim Engineering EAD, and in 2023 she was appointed as an Assistant Lecturer in the Department of Electrical Power Engineering and Communications at the Faculty of Physics and Technology, University of Plovdiv "Paisii Hilendarski."

Since March 2022, she has been enrolled as a full-time doctoral student in the Department of Electronics, Communications and Information Technologies (ECIT) at the Faculty of Physics and Technology, University of Plovdiv "Paisii Hilendarski," in the field of higher education 5. Technical Sciences, professional field 5.3 Communications and Computer Engineering, doctoral program Automation of Areas of the Intangible Sphere (medicine, education, science, administrative activities, etc.), under the supervision of Assoc. Prof. Silvia Velkova Stoyanova-

Petrova, PhD. The title of her dissertation is “Interactive Laboratory for Information Processing with Remote Access.”

Taking into account the information provided in her curriculum vitae, as well as her successful training as a full-time doctoral student at the Faculty of Physics and Technology of the University of Plovdiv “P. Hilendarski,” I can conclude that Mag. Eng. Snezha Ventsislavova Shotarova possesses the necessary educational background and practical preparation.

3. Actuality of the topic and appropriateness of the set goals and tasks

The issues addressed in the dissertation are both relevant and significant from both a scientific and an applied perspective. The topic of developing an interactive laboratory with remote access corresponds to current trends in the digitalization of education, the development of distance learning, and the need for broader access to laboratory infrastructure. Particularly important is the choice of application area—photovoltaic systems—which gives the research additional practical value in the context of contemporary energy and technological challenges.

The main objective is formulated clearly, specifically, and in accordance with the subject of the study: the development of an innovative interactive laboratory with remote access, providing an experimental and simulation environment for the investigation, control, and analysis of photovoltaic systems. The formulated tasks are logically derived from this objective and consistently cover the main stages of the research and applied work: analysis of existing solutions, selection of architectural and technological approaches, design and implementation of a web-based environment, and development of a laboratory system with real equipment and real-time data processing.

Each chapter is devoted to a specific stage in achieving the objective—from the theoretical and comparative analysis, through engineering and software design, to the actual implementation, communication architecture, data processing, visualization, and experimental validation. This correspondence between objective, tasks, and content is indicative of a well-structured scientific study.

It may be concluded that the objectives and tasks are appropriately defined, realistic, and well aligned with the structure and content of the dissertation. They provide the necessary logical framework for carrying out the research and for achieving both scientific and practical applied results.

4. Knowledge of the problem

From the content of the dissertation, it may be concluded that the doctoral candidate possesses a sufficient understanding of the research problem and of its main theoretical, technological, and applied aspects. This is evident above all from the extensive literature review and the analysis of existing solutions for interactive laboratories, in which various architectural models, classification approaches, functional characteristics, and educational applications are examined. The text makes use of a substantial bibliographic foundation, and the citations throughout the dissertation indicate that the review is based on more than 130 literature sources, covering publications approximately from 2009 to 2025, with an emphasis on more recent studies from the last decade.

A positive impression is created by the author's effort to relate the theoretical review to the practical limitations of existing solutions. Both traditional and interactive laboratory models are analyzed, with their advantages, limitations, and possibilities for application in engineering education and research activity clearly highlighted. It should also be assessed positively that the topic is considered not only in the general context of digital learning, but also in the specific application area of photovoltaic systems.

Knowledge of the problem is further confirmed by the selected research methods, which include analysis of the scientific literature and existing solutions, systems and architectural design, development and integration, as well as experimental validation and testing. This shows that the author approaches the research problem in its entirety—both as a theoretical issue and as an engineering and applied task.

In summary, it may be stated that the doctoral candidate demonstrates a solid knowledge of the problem, of the current state of research, and of the main challenges involved in developing interactive laboratories with remote access, which provides the necessary foundation for proposing an original solution.

5. Research methodology

The research methodology has been selected in accordance with the nature of the problem under consideration and with the objectives and tasks set out in the dissertation. It is comprehensive in character and involves the sequential application of theoretical, design-oriented, applied, and

experimental approaches. Methodologically, the study includes analysis of the scientific literature and existing solutions, systems and architectural design, development and integration of hardware and software components, as well as experimental validation and testing of the developed laboratory environment.

It should be positively noted that the chosen methodology does not remain only at a conceptual level, but is implemented as a consistent research process—from the analysis of existing interactive laboratories, through the selection of architectural and technological solutions, to the practical design and implementation of a web-based interactive laboratory for photovoltaic systems. In this way, the necessary link between the theoretical framework and the applied realization of the research is ensured.

An essential element of the methodology is the experimental verification of the developed system. The dissertation applies a structured validation and testing methodology aimed at verifying functional correctness, stability under load, and the suitability of the system for real use. Modular and integration tests have been conducted, along with scenarios simulating real user interaction with the remote laboratory. The functional testing covers the main subsystems—the web interface, communication with ESP32, data processing in MQTT/InfluxDB, control of the dual-axis tracker, visualization in Solar-Dashboard and Grafana, as well as the logging of user actions.

In summary, it may be concluded that the research methodology is appropriately selected, logically consistent, and aligned with the objectives of the dissertation. It makes it possible to address both the theoretical aspects of the problem and the practical implementation and experimental verification of the proposed solution, which constitutes an important strength of the work.

6. Characterization and evaluation of the dissertation work

The dissertation consists of 187 pages and is structured into an introduction, four chapters, a section entitled **“Aim and Objectives of the Dissertation”**, and concluding parts. The composition of the work is logical and consistent, with the individual structural units subordinated to the overall research concept and providing a smooth transition from theoretical analysis to practical implementation and experimental validation of the proposed solution.

The first chapter presents an analytical review of existing solutions for interactive laboratories. It examines the theoretical foundations, architectural models, classification criteria,

educational applications, and the main directions for further improvement. This chapter serves as the theoretical and analytical basis of the study and substantiates the need to develop an interactive laboratory with remote access.

The second chapter presents the architectural and technological solutions for building an interactive laboratory for photovoltaic systems. It analyzes the characteristics of photovoltaic cells and systems, measurement equipment, methods for characterizing efficiency, as well as the role of solar trackers. This chapter is important for the engineering and applied justification of the developed system.

The third chapter is devoted to the design and implementation of a web-based interactive laboratory for photovoltaic systems. It formulates the functional and non-functional requirements, presents the architecture and the technologies used, and describes the main functional modules of the system—simulations, a visual editor for PV configurations, a **“History and Analysis”** module, a control panel, a menu with training materials and exercises, security features, validation mechanisms, and graphical visualization tools.

The fourth chapter has a distinctly applied and research-oriented character and presents the development and implementation of an interactive laboratory with remote access for the study of photovoltaic systems. It examines the architectural model, hardware implementation, communication architecture, the IoT layer, the web interface, data processing in InfluxDB, result visualization, as well as the validation methodology and the results of the load tests. It is in this chapter that the main practical outcomes of the dissertation research are presented.

The main results of the dissertation may be summarized as follows: a methodology for validation and experimental evaluation of the photovoltaic system under different control and load conditions; an approach for integrating simulation models and real measurement data within a web-based laboratory environment; a functioning remote-access laboratory platform; a web-based interface for control and visualization; and a system for monitoring, analysis, and long-term storage of experimental data, including data export and the use of the InfluxDB database.

The overall assessment of the dissertation is positive. The presented work is characterized by good structure, a clearly expressed practical orientation, and a successful effort to combine theoretical analysis, engineering design, software implementation, and experimental validation. The dissertation demonstrates that the doctoral candidate has succeeded in developing a complete

and functioning solution with applicability in teaching and research practice in the field of photovoltaic systems and interactive laboratory environments.

7. Contributions and significance of the development for science and practice

The dissertation formulates contributions that may be accepted as both **scientific-applied** and **applied** in nature. They are consistent with the subject, aim, and objectives of the research and reflect results that have genuinely been achieved in the course of the study.

Among the **scientific-applied contributions** is the development of an integrated architectural model for the remote control and monitoring of photovoltaic systems, based on IoT technologies and combining the hardware layer, communication infrastructure, and web-based platform into a unified functional environment. Also contributory in nature are the proposed model for two-way real-time communication between the web interface and the physical photovoltaic system through WebSocket technology, the developed methodology for validation and experimental evaluation of the system under different control and load modes, as well as the approach for integrating simulation models and real measurement data into a web-based laboratory environment. These results are valuable because they extend existing solutions through their adaptation, integration, and application within a specific research and educational setting.

The **applied contributions** include the development of a functioning laboratory platform with remote access, intended for teaching and practical research in the field of renewable energy sources. Of practical significance are also the developed web-based control and visualization interface, the possibility of conducting simulations and real experiments without physical presence in the laboratory, and the implemented system for monitoring, analysis, and long-term storage of experimental data through web visualization, CSV export, and the InfluxDB database. It may reasonably be concluded that the developed system is characterized by good adaptability and strong potential for integration into a university and research environment.

In summary, the contributions of the dissertation may be evaluated positively. They are predominantly of a scientific-applied and applied character, contributing to the development of interactive remote-access laboratory environments and offering real usefulness for teaching and experimental work in the field of photovoltaic systems.

8. Evaluation of publications on the dissertation work

Four publications related to the dissertation have been presented, published during the period **2022–2025**, which are directly connected in content with the subject of the research and reflect the main stages of its development. These include publications in proceedings of a national scientific conference with international participation, an international scientific conference publication with a DOI, scientific proceedings of the Union of Scientists in Bulgaria, and an international scientific conference indexed in **Scopus**.

The publication activity may be assessed positively, as it demonstrates consistency in the development of the topic and an effort to present the dissertation results to the scientific community for validation. From the titles and publication venues, it is evident that the publications cover both general aspects of interactive laboratories in engineering education and more specific issues related to the development of a virtual laboratory and a web-based platform for photovoltaic systems. This corresponds to the thematic scope of the dissertation and confirms the connection between the publications and the main research work.

Through the presented scientific publications related to the dissertation, the doctoral candidate, **Mag. Eng. Snezha Ventsislavova Shotarova**, has secured **44.66 points** with respect to the minimum national requirements for publication activity, where **30 points** are required.

The presented publications are sufficient in both volume and thematic orientation to conclude that the main results of the dissertation have received the necessary public visibility and scientific validation.

9. Personal participation of the doctoral student

From the four publications presented in connection with the dissertation, which essentially reflect the results obtained in the research, there is no doubt regarding the doctoral candidate's personal involvement, and they clearly demonstrate their substantial contribution to the achieved results.

10. Abstract

The abstract is 32 pages in length and reliably reflects, in a summarized form, the content of the dissertation. It includes a general description of the dissertation, its aim and objectives, the results of the literature review presented in the first chapter, the main highlights of the doctoral

candidate's work as presented in the remaining three of the four chapters, as well as the conclusion, the principal contributions, and the scientific publications related to the dissertation.

11. Critical remarks and recommendations

Alongside the positive aspects of the dissertation, several recommendations may also be made. In certain parts of the work, the author's original contribution in relation to already existing solutions could be highlighted more clearly, particularly in the review and architectural sections.

In addition, as a direction for future development, it may be recommended to expand the experimental evaluation and to carry out further studies on the application of the developed laboratory in a real educational environment.

These remarks are of a recommendatory nature and do not diminish the overall positive assessment of the dissertation.

12. Recommendations for future use of dissertation contributions and results

The results of the dissertation have strong potential for future application, primarily in **university education**, where the developed platform could be used for conducting remote laboratory exercises, demonstrations, and practical training in the fields of photovoltaic systems, IoT, and renewable energy sources.At the same time, the proposed architectural and technological solutions have the potential to be adapted to other engineering laboratory environments where remote access, monitoring, control, and real-time data processing are required. In this regard, the contributions of the dissertation may serve as a foundation for extending the use of interactive laboratory environments in both educational and research practice.

It is also recommended that the results be further developed through the integration of additional functionalities, broader experimental validation, and implementation in a real educational environment, which would further enhance their practical applicability and scientific-applied value.

CONCLUSION

The dissertation represents a valuable scientific work, and the doctoral candidate, **Mag. Eng. Snezha Ventsislavova Shotarova**, has successfully fulfilled the stated aim and objectives.

The dissertation contains original scientific-applied and applied contributions and meets the requirements of the **Law on the Development of the Academic Staff in the Republic of Bulgaria**, the **Regulations for the Implementation of this Law**, as well as the relevant **Regulations of the University of Plovdiv "Paisii Hilendarski"** for awarding the educational and scientific degree **Doctor**.

The dissertation demonstrates that the doctoral candidate, **Mag. Eng. Snezha Ventsislavova Shotarova**, possesses in-depth theoretical knowledge and professional skills in the scientific field **5.3 Communications and Computer Engineering**, and shows the ability to conduct independent scientific research and solve research-related problems.

In view of the merits, relevance, and significance of the dissertation submitted to me for review, I give it a **positive evaluation** and propose that the Scientific Jury award **Mag. Eng. Snezha Ventsislavova Shotarova** the educational and scientific degree **Doctor** in the scientific field **5. Technical Sciences**, professional field **5.3 Communications and Computer Engineering**, doctoral programme **"Automation of Areas of the Intangible Sphere (medicine, education, science, administrative activity, etc.)"**.

25.03.2026 Prepared by:……

/prof. Dimitar Tokmakov, Ph.D/