REVIEW

by Dr. Eng. Todor Stoyanov Dzhamiykov, Professor at the Technical University of Sofia

of a doctoral dissertation submitted for the award of the educational and scientific degree of "Doctor"

in: field of higher education 5. Technical Sciences, professional field 5.3. Communication and Computer Engineering

doctoral programme "Automation in Non-Material Fields (Medicine, Education, Science, Administrative Activities, etc.)"

Author: MSc Eng. Snezha Ventsislavova Shotarova

Title: „Interactive Laboratory for Information Processing with Remote Access“

Supervisor: Assoc. Prof. Dr. Eng. Silvia Velkova Stoyanova-Petrova,

Plovdiv University "Paisii Hilendarski"

1. General Description of the Submitted Materials

By Order No. RD-22-430/23.02.2026 of the Rector of Plovdiv University "Paisii Hilendarski" (PU), I have been appointed as a member of the scientific jury overseeing the procedure for the defence of a doctoral dissertation entitled "Interactive Laboratory for Information Processing with Remote Access", submitted for the award of the educational and scientific degree of "Doctor" in field of higher education 5. Technical Sciences, professional field 5.3. Communication and Computer Engineering, doctoral programme "Automation in Non-Material Fields (Medicine, Education, Science, Administrative Activities, etc.)". The author of the doctoral dissertation is MSc Eng. Snezha Ventsislavova Shotarova – a full-time doctoral student at the Department of Electronics, Communications and Computer Engineering of the Faculty of Physics and Technology, under the supervision of Assoc. Prof. Dr. Eng. Silvia Velkova Stoyanova-Petrova of Plovdiv University "Paisii Hilendarski".

The set of printed materials submitted by MSc Eng. Snezha Ventsislavova Shotarova complies with Art. 36(1) of the Regulations for the Development of the Academic Staff of PU and includes the following documents: an application to the Rector of PU for the initiation of the dissertation defence procedure; a curriculum vitae in European format; minutes of the preliminary departmental discussion; an abstract of the dissertation; a declaration of originality and authenticity of the submitted documents; a statement of compliance with the specific requirements; a list of publications; the doctoral dissertation; copies of publications related to the dissertation. The doctoral candidate has submitted 1 copy of the doctoral dissertation, 1 copy of the dissertation abstract, and 4 publications. All publications are related to the doctoral dissertation.

2. Brief Biographical Data on the Doctoral Candidate

MSc Eng. Snezha Shotarova completed her secondary education in 1993 at the Vocational Secondary School of Light Industry and Mechanical Engineering in the town of Dospat. She subsequently studied at Plovdiv University "Paisii Hilendarski", Faculty of Physics and Technology, graduating successively: as a Bachelor Engineer in "Computer and Communication Systems" in 2019; and as a Master of Engineering in "Hardware and Software Systems" in 2020. Since 2022, she has been enrolled as a full-time doctoral student at the same faculty.

Snezha Shotarova began her professional career in 1998 in the private sector, in the field of organisation and control of commercial activities, working in various positions thereafter. Following the completion of her Master's degree, she has been employed since 2023 as an assistant at Plovdiv University "Paisii Hilendarski", Faculty of Physics and Technology.

3. Relevance of the Topic and Appropriateness of the Aims and Objectives

The topic of the doctoral dissertation is highly pertinent in view of the global trends towards the digitalisation of engineering education and the growing strategic importance of renewable energy sources. Interactive laboratories with remote access directly address the need for high-quality practical training under conditions of limited resources or the inability to maintain constant physical presence. The implementation of modern IoT solutions and cloud platforms in education creates a reliable and scalable infrastructure that meets the demands of the contemporary digital economy.

The primary objective of the work is the design and development of an innovative interactive laboratory that provides an integrated experimental and simulation environment for the study and management of photovoltaic systems. This objective has been achieved through the successive completion of tasks involving an analysis of existing solutions, the selection of a technological architecture, and the full implementation of a web-based platform and hardware installation.

The methodology employed is fully appropriate, combining a systematic review of the literature, architectural design, and comprehensive software-hardware integration. The research conducted is scientifically grounded and verified through a series of experimental validations and stress tests under real-world conditions. The adopted approach ensures a smooth transition from theoretical modelling to practical experimentation, significantly enhancing the quality of preparation of those being trained. The system demonstrates its robustness and suitability for long-term operation in educational and research environments.

4. Knowledge of the Problem

The first chapter of the doctoral dissertation presents a critical analysis of the state of the problem and existing technical solutions. The thorough and systematic review serves as the scientific foundation for defining the objectives of the dissertation. Within

the first chapter, the author conducts a detailed examination of established international platforms such as MIT iLab, VISIR, and WebLab-Deusto, classifying them according to their architectural model and functional purpose. The principal aspects through which the analysis is carried out include:

- Identification of technological limitations: It is noted that many current solutions suffer from a lack of integration between hardware and software modules, which constrains the possibilities for comprehensive engineering analysis.
- Economic and operational assessment: The analysis highlights the high cost of professional systems and the complexity of working with them, which renders them inaccessible to smaller educational institutions.
- A detailed comparison between traditional and interactive laboratories has been conducted according to criteria such as accessibility, safety, and the possibility of replication, demonstrating the advantages of remote access.
- Based on the identified shortcomings (limited personalisation and lack of real-time data support in certain models), the author substantiates the need to create a more flexible and accessible system based on open-source technologies.

A total of 143 bibliographic sources have been reviewed and interpreted in the doctoral dissertation. This extensive list encompasses a broad spectrum of materials, including: publications in prestigious international scientific journals such as IEEE and Elsevier; papers from international conferences on engineering education and technology; specialised technical resources, web pages, and official reports from organisations such as NREL, IRENA, and IEA. These are by leading, currently prominent authors — both foreign and Bulgarian scientists and specialists in the field.

5. Research Methodology

The chosen methodology is fully consistent with the stated objective of developing an innovative interactive laboratory for photovoltaic systems. It ensures a logical progression from theoretical analysis to architectural design, software-hardware integration, and final experimental verification. The principal aspects of the methodology include:

- Systematic analysis of the scientific literature and existing IoT and web-based technological solutions in the field.
- Architectural design of a three-layer model encompassing the laboratory, communication, and application layers.
- Hybrid integration of virtual simulations (MATLAB/Python) with real data from physical equipment.

- An IoT communication framework for bidirectional real-time data exchange via MQTT and WebSocket protocols.
- Experimental validation through stress tests to evaluate the stability and accuracy of measurements.

This comprehensive approach ensures the creation of a robust, flexible, scalable, and reliable educational and research platform.

6. Characterisation and Assessment of the Doctoral Dissertation

The doctoral dissertation of MSc Eng. S. Shotarova presents an innovative hybrid platform that combines virtual simulations and real hardware for remote learning in the field of photovoltaic systems. The total volume of the work is 169 pages, with the creative and analytical section spanning 130 pages (Chapters 2, 3, and 4). Chapter 1 constitutes a systematic review of the subject matter drawing upon 143 bibliographic sources and a critical analysis of existing solutions, defining the need for a higher level of technological integration.

- Chapter 2 presents theoretical and mathematical modelling of PV cells and defines the architectural requirements for dual-axis solar trackers.
- Chapter 3 covers the design of a web platform using Flask/Python, incorporating a unique visual PV editor and modules for AI-based analysis of configurations.
- Chapter 4 addresses the practical implementation of an IoT laboratory using ESP32 and MQTT communication with InfluxDB, verified through stress tests, presenting and evaluating the experimental results from the operation of the photovoltaic system.

The work is methodologically sound, of high applied value, and offers a complete cycle from theoretical modelling to practical real-time validation.

7. Contributions and Significance of the Work for Science and Practice

On the basis of the submitted doctoral dissertation, the contributions of the author are clearly defined and divided into: scientific-applied and applied contributions. I accept that the work contains both types of contributions and would summarise them as follows:

Scientific-Applied Contributions:

These contributions focus on the development of new models, methodologies, and theoretical frameworks for remote management and research.

- Integrated architectural model: A comprehensive model for remote management and monitoring of photovoltaic (PV) systems based on IoT

technologies has been developed, successfully combining the hardware layer, the communication infrastructure, and the web platform.

- Real-time bidirectional communication model: An innovative model for data exchange between the web interface and the physical system has been proposed, implemented via WebSocket technology, ensuring low latency and high reliability in the management of experiments.
- Methodology for validation and experimental assessment: A framework for testing photovoltaic systems under various load and control regimes has been created, enabling precise analysis of their efficiency under real-world conditions.
- Hybrid integration approach: A method for combining simulation models (MATLAB/Python) with real measurement data in a unified web environment has been developed, enabling direct comparison between theory and practice.

Applied Contributions:

These contributions represent the specific physical and software implementations that can be directly deployed in practice and in education.

- Functional laboratory platform: A real laboratory installation with remote access has been constructed, specially designed for the training of students and engineers in the field of renewable energy sources.
- Web-based interface (Solar-Dashboard): An accessible and scalable software environment has been developed, combining educational and engineering functions, allowing easy integration into university and research settings.
- Applied tool for simulations and experiments: A tool has been created that enables users to conduct complex experiments remotely, without requiring their physical presence in the laboratory.
- System for long-term data analysis and storage: An infrastructure has been implemented incorporating the InfluxDB database and the capability to export data in CSV format, ensuring full traceability and the possibility of subsequent scientific processing of the measurements.

8. Assessment of Publications Related to the Doctoral Dissertation

The doctoral dissertation of MSc Eng. Snezha Ventsislavova Shotarova is supported by four publications.

- One publication was presented at the 15th Annual International Conference on Education and New Learning Technologies, Spain.
- One sole-authored publication is included in the proceedings of the Union of Scientists in Bulgaria – Smolyan.

- One publication appears in the conference proceedings "Education, Science, Society".
- One publication was presented at the international scientific conference "Electronics 2025", Sozopol, indexed in Scopus.

Two of the publications are co-authored with the doctoral supervisor, while one is sole-authored. A review of the publications indicates that they cover the subject matter of the doctoral dissertation and present the achieved results to the scientific community. Their number is sufficient and meets the accepted requirements.

9. Personal Contribution of the Doctoral Candidate

The scientific-applied and applied contributions described above are reflected in publications of sufficient volume and content. They have been presented at reputable and established scientific forums in the field, which indicates that the results have gained appropriate recognition within the scientific community. I consider that the personal contribution of the doctoral candidate is manifest and unequivocally confirmed by the sole-authored publication and the co-authorship with the doctoral supervisor in the remaining works.

10. Dissertation Abstract

A careful review of the dissertation abstract confirms its full compliance with the requirements for its preparation. It adequately reflects the main positions and contributions of the doctoral dissertation. The abstract can be fully assessed and characterised as a synthesised version of the content and principal results achieved in the dissertation. It fully corresponds to the defined scientific-applied and applied contributions contained in the full text of the doctoral dissertation. In conclusion, the abstract is consistent with the doctoral dissertation with respect to structure, thematic orientation, methodology, and contributions.

11. Critical Remarks and Recommendations

The analysis of the submitted doctoral dissertation reveals a comprehensive treatment of the research conducted, the methodology, the experimental results, and the conclusions. All theoretical and practical propositions are substantiated in a correct and methodologically appropriate sequence. No explicit critical remarks or findings of weaknesses are present. Nevertheless, certain minor editorial inaccuracies and omissions may be noted, some of which provide a basis for future work on the subject:

1. Expansion of the sensor infrastructure: Although the current system successfully measures the primary electrical and climatic parameters, for more precise performance modelling in the future it would be advisable to add sensors for wind speed, humidity, and atmospheric pressure. This would

enable students to investigate more complex dependencies between environmental conditions and the efficiency of PV modules.

2. Enhancement of AI analysis towards predictive models: The present work implements an intelligent visual editor with AI-based recommendations; however, as a direction for future development, the introduction of algorithms for energy yield forecasting and predictive maintenance may be considered. Such an extension would transform the platform from a monitoring tool into a system for active energy resource management.
3. Integration of hybrid energy components: The work focuses primarily on photovoltaic systems; however, for the purposes of contemporary engineering education, it would be beneficial for the laboratory to incorporate in the future simulations of hybrid systems combining PV, wind energy, and battery storage units. This would provide a more comprehensive perspective on the operation of modern autonomous and grid-connected installations.

I consider that these recommendations and remarks will prove valuable and useful in the future scientific and publication activities of the doctoral candidate.

12. Personal Impressions

I have a limited acquaintance with MSc Eng. Snezha Shotarova, from my working visits to Plovdiv and Smolyan. My contact with her, the results presented in the doctoral dissertation, and their dissemination through scientific publications give me grounds to consider that she possesses sound theoretical and practical preparation. She demonstrates an aptitude for thorough analytical research activity employing modern research methods, which leads me to conclude that she is the author of the ideas proposed and their realisation.

I have no joint publications with the doctoral candidate. I have not observed, nor am I aware of, any elements of plagiarism in the works submitted by MSc Eng. Snezha Shotarova.

13. Recommendations for Future Utilisation of the Doctoral Contributions and Results

The applied contributions are directly usable in practice and may also find broad application in the education and training of students. With regard to the scientific-applied contributions, it is premature to make an assessment at this stage.

CONCLUSION

The doctoral dissertation contains scientific-applied and applied results that constitute an original contribution to scholarship and comply with all requirements of the Law on the Development of the Academic Staff of the Republic of Bulgaria (LDASRB), the

Regulations for the Implementation of the LDASRB, and the corresponding Regulations of PU "Paisii Hilendarski".

The doctoral dissertation demonstrates that the doctoral candidate, MSc Eng. Snezha Ventsislavova Shotarova, possesses in-depth theoretical knowledge and professional skills in scientific specialty 5. Technical Sciences, professional field 5.3. Communication and Computer Engineering, and displays the qualities and abilities required to independently conduct scientific research.

For the foregoing reasons, I confidently give my positive assessment of the research conducted, as presented in the doctoral dissertation, abstract, results, and contributions reviewed above, and I propose that the esteemed scientific jury award the educational and scientific degree of "Doctor" to MSc Eng. Snezha Ventsislavova Shotarova in field of higher education: 5. Technical Sciences, professional field 5.3. Communication and Computer Engineering, doctoral programme "Automation in Non-Material Fields (Medicine, Education, Science, Administrative Activities, etc.)".

Date: 26.02.2026

Reviewer: .....

(Prof. Dr. Todor Djamiykov)