REVIEW
of a dissertation
submitted for the award of the educational and scientific degree "Doctor (PhD)" in

field of higher education – 5. Technical Sciences
professional field – 5.3. Communication and Computer Engineering
doctoral program – Automation of Engineering Work and Computer-Aided Design Systems
Author: M.Eng. Ilian Tsvyatkov Varbov
Title: *MODELING AND SIMULATION OF COMPONENTS OF COMPUTER SYSTEMS*
Reviewer: Prof. Dr. Eng. Miroslav Nikolov Galabov

This review has been prepared on the basis of Order No. 3-01-143 dated March 31, 2026, issued by the Rector of the Technical University of Gabrovo.

1. Topic and Relevance of the Dissertation

The topic of the dissertation is focused on the study of methods and tools for the design, modeling, and simulation of fundamental hardware components of computer systems through the use of modern hardware description languages and specialized simulation environments.
The relevance of the research is determined by the increasing complexity of contemporary computer systems and the need for effective methods for their design, verification, and optimization. In the context of the rapid development of microelectronics and programmable logic devices (FPGA), the modeling and simulation of hardware components have become an essential stage in the process of digital system development.
The use of hardware description languages such as VHDL, Verilog, and TL-Verilog, as well as modern simulation environments, enables the creation of functional and synthesizable models that can be analyzed and optimized prior to their physical implementation.
In this context, the topic of the dissertation is relevant both from a scientific and an applied perspective, as it is related to methods for designing microprocessor architectures and digital systems used in both academic research and industry.

2. Review of the Cited Literature

The dissertation presents a systematic and focused review of the scientific literature, covering key areas related to the modeling and simulation of computer system components. The analysis includes a total of 47 references, encompassing both fundamental theoretical works and contemporary applied solutions in the fields of computer architectures, HDL technologies, and FPGA-based implementations.
The literature review is logically and thematically structured, with the main emphasis placed on existing implementations of microprocessor architectures, particularly those of the RISC type. A number of well-established and widely used projects are examined, such as Rocket Chip

Generator, VexRiscv, Ibex Core, CV32E40P, OpenRISC, LEON3, NEORV32, AVR Core, and OpenSPARC, which demonstrates a solid understanding of the current state of research in the field.

Special attention is given to the comparative analysis of hardware description languages—VHDL, Verilog, and TL-Verilog—highlighting their advantages, limitations, and applicability at different levels of abstraction. This indicates an in-depth understanding of the tools used in digital system modeling. In addition, leading simulation environments such as Vivado, ModelSim, Verilator, and Makerchip are analyzed, contributing to a comprehensive evaluation of verification and testing methods.

The review clearly shows that the author has identified existing limitations of current implementations, including their complexity, orientation toward industrial applications, and limited applicability in educational environments. This critical analysis serves as a foundation for formulating the research problem and justifying the need for developing more flexible, modular, and comprehensible models of computer systems.

Despite the good coverage of the reviewed sources, it may be noted that the review is more strongly focused on technical implementations and less on the latest publications in high-impact international journals, which could further enrich the theoretical part and enhance the scientific contribution of the study.

In conclusion, the literature review is appropriate to the topic, demonstrates a good understanding of the state of the art, and provides a solid theoretical foundation for the subsequent research and developments presented in the dissertation.

3. Research Methodology

The research methodology applied in the dissertation is characterized by a consistent, systematic, and experimentally oriented approach, combining theoretical analysis, modeling, simulation, and practical implementation of the developed solutions.

At the core of the study is the application of modern methods for functional and structural modeling of computer system components, implemented through hardware description languages such as VHDL, Verilog, and TL-Verilog. Using these, models have been developed at various levels of abstraction—from individual digital circuits to complete microprocessor architectures at the register-transfer level (RTL).

The methodology includes several main stages. First, an in-depth analysis of existing architectures and approaches is conducted, serving as the theoretical foundation for the development of original models. Based on this analysis, requirements for the models are formulated, related to their functionality, synthesizability, and applicability in real hardware environments.

The next stage involves the creation of models of key computer system components—arithmetic logic units, memory, registers, multiplexers, decoders, and other digital circuits. For each of these, alternative implementations in different HDL languages are developed, enabling comparative analysis and evaluation of their efficiency.

A key element of the methodology is the simulation-based study and verification of the developed models. For this purpose, established environments such as ISim, Vivado, ModelSim, and Makerchip are used, allowing monitoring of system behavior, error detection, and analysis of

functional correctness. Testing is performed using specially developed test programs, including assembly-level scenarios for validating microprocessor models.
Following the simulation phase, a practical implementation on an FPGA platform is carried out, which constitutes an important part of the experimental methodology. This implementation enables evaluation of hardware resource utilization, performance, and operational reliability of the developed models in a real environment.
The methodology also includes a comparative analysis of different approaches and technologies, assessing metrics such as implementation complexity, resource usage, and functional efficiency. This allows for drawing well-founded conclusions regarding the applicability of the proposed solutions.
In summary, the applied methodology is appropriate to the objectives of the dissertation, integrates both theoretical and experimental approaches, and provides a reliable foundation for the obtained scientific and applied results.

4. Contributions of the Dissertation

Based on the content of the dissertation, the following scientific and applied contributions can be identified:

1. Models of fundamental digital circuits and functional blocks of computer systems have been developed using the hardware description languages VHDL and Verilog.
2. Models of a RISC-based microprocessor have been created using TL-Verilog, Verilog, and VHDL, accompanied by a comparative analysis of the different modeling approaches.
3. A model of a microprocessor with AVR architecture at the register-transfer level has been developed.
4. An implementation of the developed microprocessor model on an FPGA platform has been carried out, along with its simulation and analysis.
5. An evaluation of the performance and resource efficiency of HDL models implemented on FPGA has been conducted, which can be used to optimize future projects.
6. A comparative analysis of existing developments and the proposed microprocessor models with RISC and AVR architectures has been performed.

5. Publications and Citations Related to the Dissertation

A total of 7 publications related to the dissertation have been presented, in which the main results of the conducted research are published. This currently corresponds to 60 points, compared to the required minimum of 30. Therefore, the PhD candidate has fulfilled the minimum national requirements under Art. 2b, para. 2 and 3 of the Academic Staff Development Act, as well as Art. 24, para. 1 of the Regulations for its implementation.
The publications reflect the development of models of digital components, microprocessor architectures, and their modeling using HDL languages. They present the results obtained from the simulation and analysis of the developed models.
There is no information provided regarding citations.

6. Authorship of the Obtained Results

Based on the presented abstract, it can be concluded that the main results of the dissertation are the personal work of the PhD candidate and represent an independent research contribution.
The development of models of digital circuits and computer system components, as well as the creation of microprocessor models with RISC and AVR architectures, has been carried out by the author using modern hardware description languages (VHDL, Verilog, and TL-Verilog). The proposed solutions, including the implementation of arithmetic logic units, memory units, registers, and control blocks, demonstrate a consistent and focused research effort conducted independently by the candidate.
A particularly significant contribution of the author is the development of a microprocessor model with AVR architecture at the register-transfer level and its implementation on an FPGA platform. This implementation requires the integration of multiple functional blocks, implying a high degree of independence and in-depth knowledge in the field.
The obtained results have been verified through simulation studies and experimentally validated in a real hardware environment, further supporting their reliability and originality. The test programs used and the analysis of the results are also part of the author's research work.
The results of the dissertation have been disseminated through publications and participation in scientific conferences, which further confirms their originality and authorship.
In conclusion, it can be stated that the presented scientific and applied results have been developed independently by the PhD candidate, demonstrating the ability to conduct a complete research process—from theoretical analysis, through modeling and simulation, to practical implementation and experimental verification.

7. Abstract and Author's Contribution Statement

The submitted abstract presents, in a concise and well-structured manner, the main results of the dissertation, accurately reflecting its objectives, tasks, applied methods, obtained results, and scientific contributions. The content of the abstract is logically consistent and covers all essential aspects of the research—from the analysis of the state of the problem, through the development of component models and microprocessor architectures, to their simulation and practical implementation on an FPGA platform.
The structure of the abstract is clear and well organized, including a general overview of the dissertation, a chapter-by-chapter summary, scientific novelty, applicability, and validation of the results. The information provided is sufficient to form a comprehensive understanding of the scope and significance of the conducted research. The length and level of detail are consistent with the requirements for this type of scientific work.
The author's contribution statement correctly summarizes the scientific and applied contributions of the dissertation. The identified contributions are clearly distinguished and correspond to the content of the dissertation, reflecting the development of microprocessor architecture models, the creation of synthesizable solutions, and their FPGA implementation. There is consistency between the stated contributions and the results presented in the individual chapters of the work.
The publication activity of the PhD candidate, as reflected in the abstract, shows that the main results have been validated through participation in scientific forums, which contributes to their

scientific credibility and visibility. However, it may be recommended to expand publication activity in journals with higher impact factors and broader international recognition.
In conclusion, the abstract and the author's contribution statement meet the established requirements, providing clear, accurate, and sufficiently comprehensive information about the dissertation, its results, and the author's contributions.

8. Opinions, Recommendations, and Remarks on the Dissertation

Alongside the undeniable strengths of the dissertation, several remarks and recommendations can be made:

1. The literature review could be further expanded to include a broader analysis of contemporary developments related to System-on-Chip (SoC) and multicore architectures.
2. It would be beneficial to present more detailed quantitative results from the simulations, as well as comparative evaluations between the different models.
3. In some parts of the text, stylistic inaccuracies are present, which could be revised to improve clarity of presentation.
4. A more detailed analysis of the potential practical applications of the developed models in industrial systems could be provided.

These remarks do not diminish the scientific value of the dissertation, but rather have a recommendatory character.

9. Conclusion

I consider that the submitted dissertation meets the requirements of the Academic Staff Development Act. The achieved results provide sufficient grounds for me to propose that the educational and scientific degree "Doctor (PhD)" be awarded to M.Eng. Ilian Tsvyatkov Varbov in field of higher education – 5. Technical Sciences, professional field – 5.3. Communication and Computer Engineering, doctoral program – Automation of Engineering Work and Computer-Aided Design Systems.

April 17, 2026

Signature:
/ Prof. Dr. Eng. M. Galabov /