

# REVIEW

of a dissertation for the award of the Educational and Scientific Degree “Doctor of Philosophy (PhD)”

**in the Field of Higher Education:** 5. Technical Sciences

**Professional Field:** 5.3. Communication and Computer Engineering

**Doctoral Program:** Automation of engineering work and automated design systems

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**Topic:** "Modeling and Simulation of Computer Systems Components"

Member of the scientific jury: Prof. Stanislav Simeonov, PhD

Burgas State University "Prof. Dr. Asen Zlatarov"

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## **1. Relevance of the problem addressed in the dissertation in scientific and applied scientific aspects**

The development of computer technologies in recent decades has been characterized by a continuous increase in complexity, as well as processes of miniaturization and a higher degree of integration. Traditional approaches to manual design and testing are no longer effective enough in the development of modern microprocessors, memories and peripheral devices. For this reason, modeling and simulation of hardware components are becoming an obligatory part of the design process. They provide an opportunity for early detection of errors, improvement of architectural solutions and reduction of the time required for development.

The topic of the presented dissertation is interesting and relevant. It is related to research activities regarding modeling and simulation of basic components of computer systems.

At the very beginning of the Dissertation (p. 7) the goal of the Dissertation is defined: to develop and analyze models of basic components of computer systems using modern languages for describing hardware and simulation environments, to create and implement a model of a microprocessor with AVR architecture on an FPGA platform.

To achieve this goal, the following tasks are set for solving:

1. To analyze the state of research in the field of modeling of computer systems and components.
2. To develop models of digital circuits and basic components of computer systems using modern languages for describing hardware VHDL and Verilog.
3. To study the developed models of digital circuits and basic components of computer systems.
4. To develop models of a microprocessor with RISC architecture using the hardware description languages TL-Verilog, Verilog and VHDL.
5. To study the proposed models of a microprocessor with RISC-V architecture.
6. To develop a model of a microprocessor with AVR architecture at the register level.
7. To implement a model of a microprocessor with AVR architecture on an FPGA platform.

The following hypothesis is also formulated: the use of HDL languages and modern simulation environments enables greater accuracy in modeling hardware blocks, reduces development time, and leads to more effective architectural solutions.

## **2. Degree of knowledge of the state of the problem**

The PhD candidate demonstrates in-depth knowledge of the state of the problems on the topic of the dissertation, expressed both through the scope and depth of the interpretations of the sources used in the literature review. The list of literature used includes 47 sources. The literature sources are up-to-date. It can definitely be said that they are known by the author practically in full and are the basis for the development of the proposed work. All sources have been duly cited.

## **3. Content and results of the dissertation work**

The dissertation work has a total volume of 197 pages. It is structured in an introduction, four chapters, contributions, a list of publications on the topic of the dissertation, a list of used literature and two appendices. Each of the chapters ends with conclusions.

The first chapter, entitled "Analysis of the state of the topic of the dissertation", presents the main components of computer systems and their functions. The languages for describing hardware, their applications and advantages, as well as the basic principles of computer modeling and simulation are examined. The environments used for modeling and simulating hardware components are presented. The comparative analysis between the languages for describing the hardware part, based on their main characteristics (p. 23), makes a very good impression. At this point, a conclusion could be added regarding the author's preferences regarding this comparison, with the specific reasons for this. The comparative analysis between the simulation environments (p. 29) is more valuable due to the presence of a motivated solution. On p. 30, based on the literature review, the goal and tasks of the present work, which I mentioned at the beginning of the review, are defined.

I assume that the PhD – student complied with internal requirements for TU – Gabrovo, which I personally did not notice in the university regulations.

The second chapter is devoted to the modeling and simulation of basic digital circuits and functional blocks used in computer systems. The created models of arithmetic-logic devices, memory, multiplexers, counters, registers and other elements, built with different HDL languages, are presented. The presented material is illustrated with numerous diagrams, graphs and simulations.

The third chapter examines the process of modeling RISC architectures of microprocessors using the hardware description languages VHDL, Verilog and TL-Verilog. The created models and the results obtained from their simulation are presented. These models allow to trace the process of operation of the microprocessor in the individual stages of processing instructions. The results of the simulations confirm the correctness of the proposed models.

The fourth chapter presents the modeling of a microprocessor with AVR architecture and its implementation on an FPGA platform. The operation of the individual blocks, the synthesis and simulation of the entire model, as well as its applicability in the design of hardware systems are analyzed. Modeling a processor with AVR architecture, which is an 8-bit RISC microcontroller architecture designed for efficient instruction execution and low power consumption. These architectures are based on the Harvard architecture, in which program and data memory are separated. This allows for simultaneous instruction fetching and data processing. The processor core has 32 universal 8-bit registers, which are directly connected to the arithmetic-logic unit. Thanks to this organization, most instructions are executed within a single clock cycle, which provides high performance in embedded systems. The AVR architecture is widely used in various microcontrollers,

#### **4. Contributions of the dissertation**

I accept the results achieved in the doctoral dissertation, and I define the presented contributions as applied and applied, personally dividing them as follows:

##### **I. Scientific and Applied Contributions**

1. Models of basic digital components of computer systems have been created - arithmetic-logic devices, random access memory, multiplexers, demultiplexers, encoders, decoders, counters, registers and comparators - implemented using the hardware description languages VHDL and Verilog.
2. Models of microprocessors with RISC architecture have been developed based on the hardware description languages TL-Verilog, Verilog and VHDL. Through these models, the organization and interaction between the main blocks - arithmetic-logic device, register file, memory and control block have been studied.
3. A microprocessor model with AVR architecture at the register level has been developed.

## **II. Applied contributions**

1. A microprocessor model with AVR architecture has been implemented on an FPGA platform.
2. An assessment of the performance and resource efficiency of HDL models when implemented on FPGA has been made, which can be used for optimization of future projects.
3. A comparative analysis of existing developments and proposed models of microprocessors with RISC and AVR architectures has been made.

### **5. Publications and citations of publications in the dissertation work**

7 publications are attached to the documents. All publications were made during the doctoral studies. I assume the participation of the doctoral student in all publications to be equal. The publications are referenced in the international database "Scopus". After checking in the Scopus database, I personally saw more publications that are not included in the list. I believe that these publications contain the main contributions claimed in the dissertation. The articles are mainly coauthored with the supervisor, which personally makes a very good impression on me.

### **6. Notes on the dissertation work**

In principle, I have no comments on the substance of the dissertation work. Regarding the layout of the explanatory note, I can recommend:

- when preparing such materials, short sentences should be used. The way of expressing with long sentences in places can mislead readers;
- it would be good if most of the modeling were only in the applications. In the work itself, only principle solutions with pseudocode should be presented;
- I would recommend to the colleague to continue the work by creating pipeline architectures and even entire simulators. In this regard, I recommend the book: Bryant B., O' Hallarion D., Computer Systems: A Programmer Perspective 3rd Edition, Pearson Education, 2017 ISBN-13: 978-0-13-409266-7.

The stated recommendations do not belittle the work of the PhD – student, and I hope that the work on the scientific topic will continue, because it is interesting and relevant. Work in this direction is of scientific interest to me as well.

### **7. Conclusion**

The topic of the dissertation is relevant and interesting. Scientific-applied and applied results of importance for theory and practice have been obtained. The results of the conducted research are significant enough for a procedure for awarding an educational and scientific degree "PhD", in area 5. Technical sciences, professional field: 5.3. Communication and computer engineering, doctoral program: Automation of engineering work and automated design systems Through the

publications made, the scientific community has been given the opportunity to familiarize themselves with the conducted research and obtained results. The PhD – student has completed full-fledged training in doctoral studies and clearly shows opportunities for independent scientific work.

Taking into account the above, I believe that the requirements for developing a dissertation for the educational and scientific degree "PhD" have been met and I give a positive comprehensive assessment.

By evaluating the author's research work and published scientific production as a whole, I give my positive opinion regarding the awarding of the educational and scientific degree "PhD" to Mag. Eng. Ilian Tsvyatkov Varbov, wishing him success.

04.05.2026 г.

Reviewer: \_\_\_\_\_

/Prof. Stanislav Simeonov, PhD/